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ADJUVANTIBUS

L. GALLÉ, I. KISS, M. MARIÁN, L. MÓCZÁR

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MANAGEMENT OF WATER-SUPPLIES IN THE TISZA RIVER BASIN

I. NAGY

Authority of Water Management for the Middle Course of Tisza,
Szolnok, Hungary
(Received 30 June, 1975)

The waters of the Eastern half of the Carpathian basin are collected by the Tisza and carried into the Danube. The watershed area of the approximately 1,000 km long river is about 157.000 sq.km. Its importance in the life of Hungary is shown by that about the half of the country falls to the watershed area of the Tisza.

The Pannonian sea that used to take up the place of the Hungarian Great Plain, was mostly filled up at the beginning of the Pleistocene with the alluvial deposit of the rivers discharging here from the adjacent ring of mountains. The rivers — thus the Tisza, as well — for lack of a definite gradient, looked for a way meandering vaguely and changing their beds. The floods of the rivers overflowing year by year, together with the rainwater missing any downflow, have increased marshes. That is the cause that in this region, even one and a half centuries ago, but a few hundred thousand people could manage to subsist.

There were these circumstances the Hungarian water-conservancy programme of the Nineteenth Century arose from, having as primary aims the protection against floods, river control, land drainage.

The decisive motive to begin the regular river control works was given by the floods of the Tisza in 1844/45, destroying the town Szeged, as well. Then the Tisza control was taken over by ISTVÁN SZÉCHENYI who considered as a precondition of the economic and cultural development of the country to overcome floods and solve water control. The plan of Tisza control was elaborated by PÁL VÁSÁRHELYI, the excellent water engineer of that age. Works began in 1846. The rivers of the Tisza basin were diverted in regulated beds, the floods were kept within dams by the large water works of the Nineteenth Century — called a second conquest of Hungary. In that way, the land was rendered suitable for cultivation and habitable, and life could begin to move on the way of the economic development. As a result of that, in the Tisza basin about 1,5 million ha. land could be conquered from waters. The reclamation of the affluents and their mouth area and a further development of the system realized took place in our century.

The possibility of land utilization and development has been created in about 20 per cent of the country by the protective system developed in this way.

Today already 40 per cent of the population of our country is living here, concentrating here 42 per cent of the national wealth of the country. Here lies one-third of the cultivated fields of the country. More than 50 per cent of the agricultural production of the country and 70 per cent of the industrial production of the country come from this region.

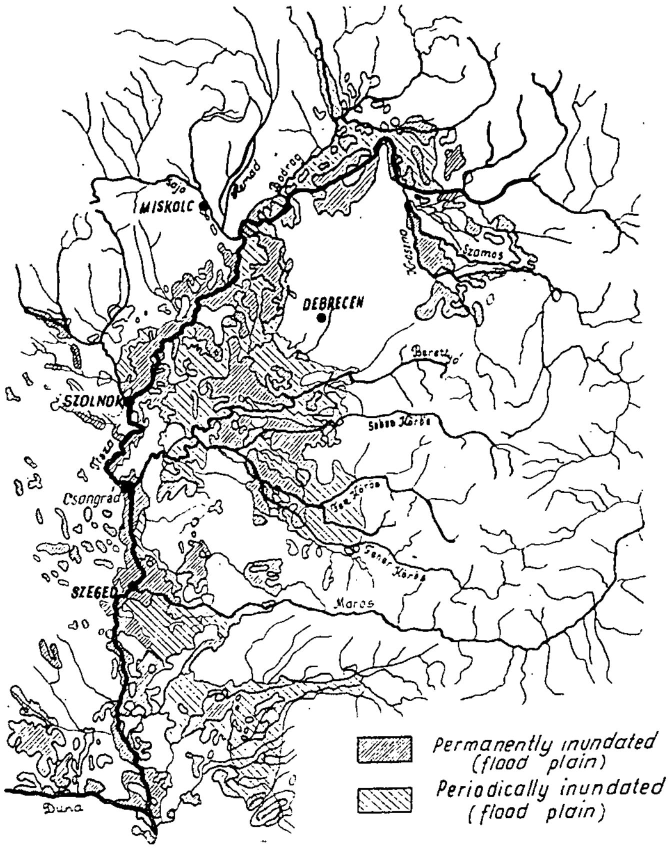


Fig. 1. Hydrographic map of the Tisza basin before the regulation of water-ways

The task of the present century is fundamentally the utilization of the existing stock of water, first of all the agricultural water utilization (irrigation, fish-pond economy), and it becomes more and more necessary, as well, to develop the industrial and drinking-water supply, shipping and river-side health resorts.

The Tisza basin is one of the most favourable regions in the Carpathian basin to agricultural production. But the many years average of precipitation falls short of 600 mm, and in a large part of the region even short of 500 mm.

The average precipitation of the growth season is 300 to 350 mm, falling in certain years even to 175 mm. The average number of sunny hours exceed 2,000. The water deficiency arising from the difference between the possible evaporation and precipitation in the middle region of the Great Plain reaches 175 mm in the average of 50 years. The aridity-factor having a high influence on plant cultivation is formed between 1.2—1.4; the area is, therefore, of droughty character.

In the middle part of the Tisza basin water is a production factor available but to a minimum extent. A precondition of developing the forces of production in this area is to have water of sufficient quantity and quality and in a distribution of time and space as demanded by development.

Four-fifth of the Great Plain can be supplied with water for irrigation mainly from the Tisza. The annual formation of downflow is unfavourable from the point of view of agricultural production. The water movement in the Tisza is highly extreme. Its water output alternates between 50 to 4700 cc. m/sec. The smallest water outputs are first of all in Summer and late Summer, in the season of irrigation demands.

From this peculiarity of water conditions arises one of the most outstanding tasks of the water economy of the Tisza basin, to equilibrate the fluctuations of water outputs, regulating the discharge of the quickly flowing water with river barrages, bed and flood-plain reservoirs.

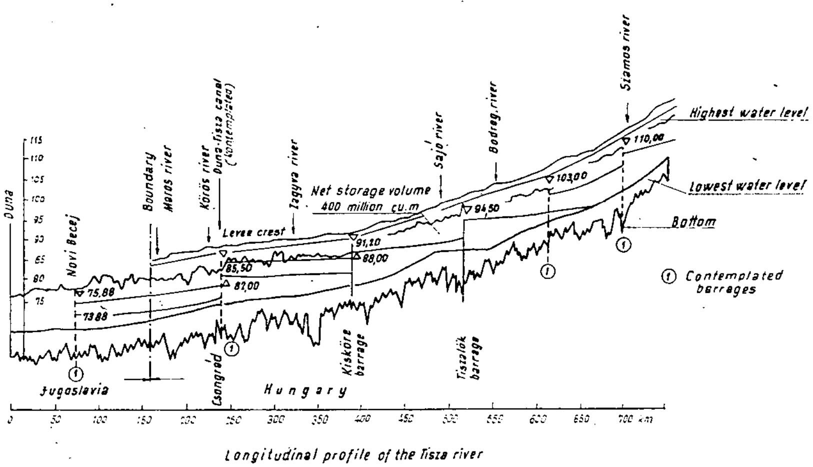


Fig. 2. Longitudinal section of the Tisza canalization

The Conception of Developing the Management of Water-Supplies in the river Tisza, approved by the Government of the Hungarian People's Republic at the beginning of 1973, is providing for canalizing the Tisza by building a series of river barrages.

In the framework of this multipurpose, extensive water-economy programme, there are being built five river barrages in the Hungarian Tisza stretch and one barrage in the Jugoslav stretch. By means of the river-barrage series, the utilization of Tisza water for the aims of the population, industry, agriculture, and for other purposes too, the regulation of natural downflow along the Tisza, and the distribution water in the Tisza basin are made possible. The barrages are creating a continuous water-way, utilizing the hydraulic power of the river — first of all for producing peak energy.

From among the river barrages, the River Barrage at Tiszalök was built first, in 1954. Its fundamental task is to supply with water the irrigation of 150,000 ha. of the Water-Economy System at Tiszalök, to satisfy the water-demand of industry and population and to provide with water the Kőrös basin, through the East-West Main Canal of a total 60 cc.m/sec. water-removal capacity and branching off from the Tisza above this river barrage. The output of the hydroelectric power station is 14 MW, for 55 million kWh annual average production — mostly peak energy. As a result of damming, in the Tisza and Bodrog a 130 km long water-way was produced, navigable with larger ships, too, and in the river-bed the storage of 10 million cc.m water became possible.

In 1973, as second, the Kisköre River Barrage was put in operation. The next one will be built at Csongrád, and the Danube—Tisza Canal will join the Tisza above that. This canal will serve for the water supply of the Tisza basin from the Danube. It will connect the navigable water-way of the Danube — that will essentially grow wider after creating the Danube—Main—Rhine-canal, — with that in the Tisza, shortening strongly the line of the East-Western water transport, when the Csongrád Water Barrage is built in the developmental period after 1985. The fourth river barrage will be realized in the area of Dombrád, and the fifth in that of Vásárosnamény.

In the Jugoslav Tisza stretch, the river barrage being built at Új-Becse draws to be finished.

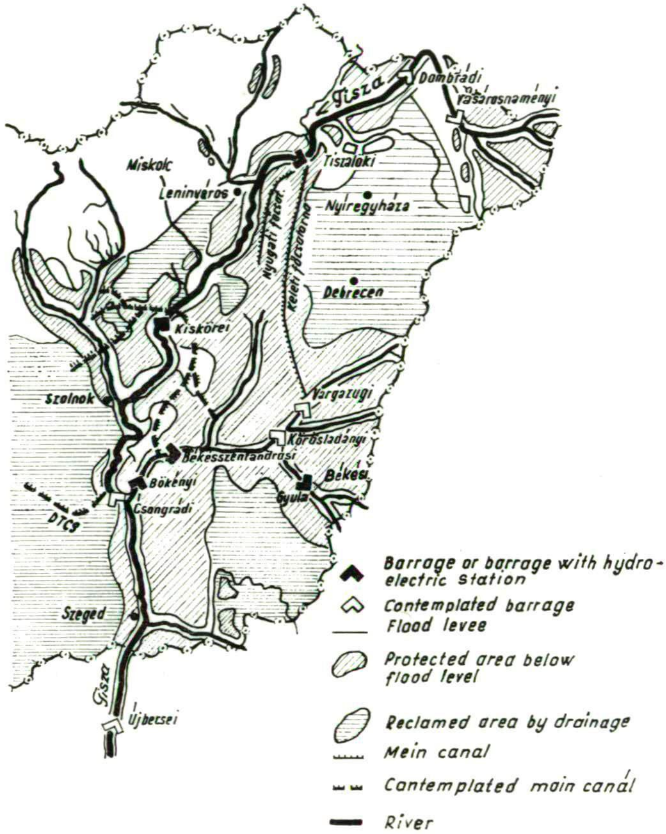


Fig. 3. Major establishments of water economy in the Tisza basin

As a result, a finishing the Tisza canalization and building the Danube—Tisza canal, the widening of the further economic development of the area and a strong development of water traffic are to be expected.

The building of the Kisköre River Barrage and its establishments was ordained — in accordance with the importance of the work — by Act II of 1966 about the Third Five-Year Plan of the people's economy.

The building of the river barrage began in 1968 and it was put in operation in 1973.

In the profile of the river barrage the most significant hydrographic data are the following: the watershed area is 66,000 sq.km, the smallest resp. largest water output observed so far are 56, resp. 3620 cc.m/s, the mean water output is 530 cc.m/s. The large water of 1 per cent probability is 4,032 cc.m/sec.

The aim of the river barrage is:

— to augment the utilizable water supply in the affected stretch of the Tisza, by equalizing the downflow conditions, with 300 million cc.m storing capacity and 144 cc.m/s water output, and later, in the long-range project, with 400 million cc.m storing capacity and 175 cc.m/s water output;

— to satisfy the increasing agricultural and industrial water demands, mostly in gravitational way, solving the water supply of 300,000 ha. area to be irrigated, 12,000 ha. fish-pond, and that of various industrial plants;

— to increase the safety of flood-prevention by means of the strengthened dams of the reservoir, and to protect the areas along the dams, by means of the oozing canal system, from the "springing" waters that earlier went along with floods;

— to product 103 million kWh energy, first of all peak energy, a year;

— to create a 120 km ship-way, suitable for the traffic of 1350 t ships;

— to stop partly the draw-off with pumping installation in the 120 km stretch of the Tisza affected by damming; to decrease the neight of noisting at the remaining installations;

— to establish resting and sporting possibilities by means of the 127 sq.km water surface of the reservoir.

The main parts of the system of establishments are: the river barrage, the river stretch dammed, and the reservoir, as well as the irrigation system in the districts Nagykunság and Jászság in Eastern Hungary.

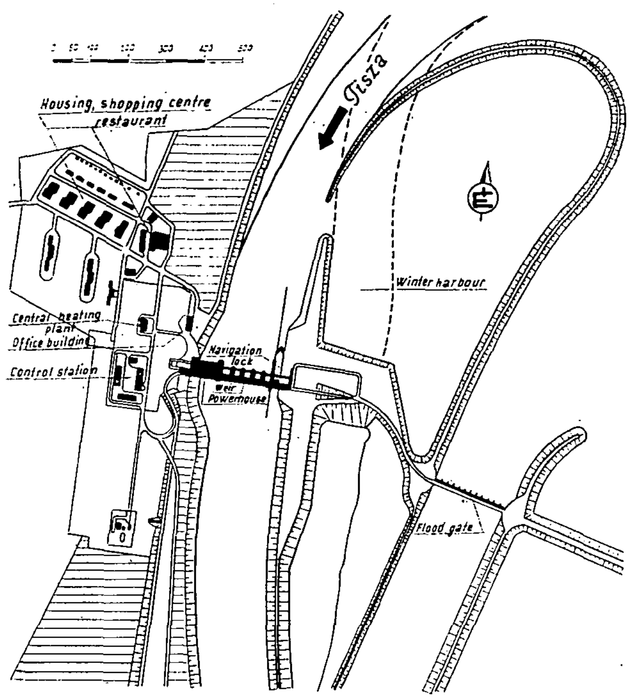
The river barrage was built in the Tisza section at river-km 404, in a right-bank cutting, on the confines of the community Kisköre. The river barrage consists of three engineering structures built together (water power plant, weir, locking), of the flood-plain dam and of river-side establishments.

The built-in water output of the water power station is 560 cc.m/s, utilized by means of four tube-turbines with 6.3 m design fall, each of them swallowing 140 cc.m/s water and having a horizontal axis of 4.3 m wheel diameter, running at 107 rev. p. m. The utilizable fall is 2.0 to 10.7 m. The rated power of generators is together 28 MW.

The weir has five openings with raised sills, each of them being 24 m broad. The barring gear is a tainter gate with electrically controlled tipping board. The operation of the barrage is controlled from the control point placed at the right bank of the river.

The lock is placed on the left of the weir, in the headwater. The useful ground-space of its chamber is 85 by 12 m, its useful depth is 3 m. Its size corresponds to the international directives concerning the fourth-class shipways.

The reservoir formed — owing to the damming — 40 km long between Kisköre and Tiszabábolna in the flood-plain between the dams, as well as the dammed river stretch (reach) between Kisköre and Tiszalök are connected close to the river barrage, forming integral part of that. The water surface of the reservoir is 127 sq. km, its useful capacity is — in case of a long-range formation of a maximum damming of 91.20 m A. O. D. — 400 million cc.m. Its maximum width is 6 km, average water-depth 2.5 m. From the reservoir 180 cc.m/s irrigating water can be obtained in 80 per cent of years.



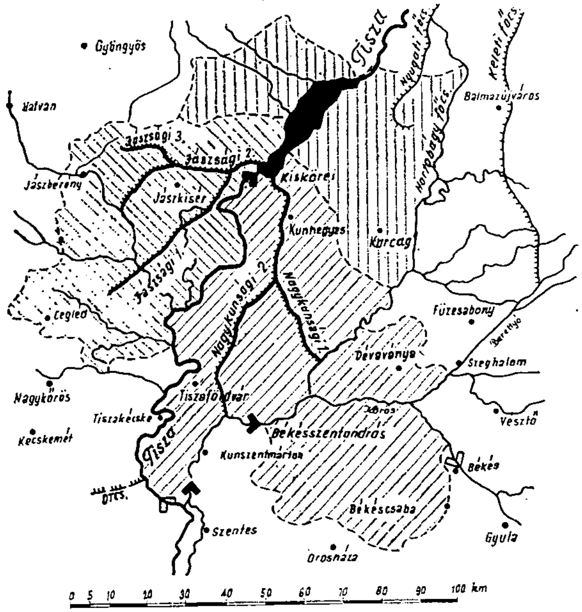
Arrangement of the Kisköre Barrage

Fig. 4. General plan of the Kisköre River Barrage

The reservoir is created gradually. In the first time the lower section of the reservoir was built, at both river-sides about 19 km long, having begun to operate in 1973. That enables a bed-damming between the levels 87,50 to 88.50 m A. O. D. providing 40 million cc.m storing capacity. At the second step, till 1978, the 88.50 m damming level already reaches the feet of dams in some places, by covering the flood-plain. The complete building of the reservoir is a task of the second and third steps. In this period will also be built the resort and recreation area round the reservoir.

From the left bank of the Kisköre Reservoir, 4 km from the river barrage, the main canal in Nagykunság forks off. Its water transporting capacity is 80 cc.m/s. It provides partly for the irrigation water of 130,000 ha. area, partly for the water supply of the Kőrös basin. The main canal in Jászság forks off from the right bank of the Tisza, 1 km from the water barrage. Its water transporting capacity is 48 cc.m/s. It supplies with water a 70,000 ha. area, partly in gravitational way.

As we think with justified pride on that this great work will serve for the welfare of the population in this area of Hungary even in the next century, we owe respect at the same time to the memory of István Széchenyi, Pál Vásárhelyi, and their co-workers, to the thousands of reputed and nameless specialists, ingeneers, technicians, workers, builders, excavator-operators and bankers in the reform era who, from the period of pioneering work till our present days, all contributed to the porsperity of the Tisza basin, realizing by means of their unselfish efforts this great programme of the economy of water-supplies.



Barrage (or barrage with hydroelectric station)

Main canal

Fig. 5. General plan of the Kisköre Water Barrage and its main works

In the framework of that nature-transforming programme, the biological equilibrium of the Middle Tisza Region and first of all that of the Reservoir of 127 sq.km size will change. We want to publish our results and establishments, achieved in the course of investigating these, in the present volume of Tiscia.

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FACTORS, NATURAL FUNDAMENTALS, AND ARTIFICIAL EFFECTS DETERMINING THE HYDROECOLOGICAL STATE OF THE RIVER TISZA

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(Received 30 June, 1975)

Abstract

The paper is dealing with natural fundamentals and artificial interventions that are necessary to evaluate the hydrochemical and hydrobiological investigations carried out in the Tisza

Introduction

The hydroecological state of the Tisza water is a function of a great many factors.

At evaluating the results of investigations, we have to take into consideration the formation of the most important factors influencing the chemical composition of, and biological changes in the Tisza, among these the effects of natural fundamentals and artificial interventions.

The geological development of the Tisza was treated of by RÓNAI (1966), the properties of its watershed area by BOGDÁNFFY (1924), ANDÓ (1969), the conditions of its water output, water level, and alluvial deposit by KORBÉLY (1937), LÁSZLÓFFY—BÖHM (1932), MEZŐSI—DONÁTH (1952), and ANDÓ—VÁGÁS (1974), in the fullest detail.

The "limnophysiographic" characterization of the Tisza and its affluents were summed up by UHERKOVICH (1971), on its chemical composition we were informed by the annual publication of "VIKÖZ", entitled: "Alapadatok a vízminőséggazdálkodáshoz" (Fundamentals to the water-quality economy).

Apart from the natural fundamentals of the Tisza, in our days we have to take into account also the effects of some artificial interventions like damming, storing, urbanization, industrial and agricultural activities, as well as the extraordinary pollutions.

Natural fundamentals

The Tisza may be included among the young rivers in geological sense, having the age of hardly a few ten thousand years.

The emergence of the Nyírség (a district in North-Eastern Hungary) diverted the rivers of the Northern Great Plain in western direction, compelling them to join, and the movements of the earth that had played a part in forming the present-day Danube—Tisza Interstream Region, drove the Danube to the edge of the Transdanubian platform.

The broad basin between the two hilly countries rising above the surroundings in this way was taken up by a new river, the Tisza. That was from the beginning a main river, joining almost all the waters of the Great Plain.

The watershed area of the Tisza, in a narrow sense, — about 13,173 sq.km — extends till the mouth of the Szamos. It is mostly a mountainous and hilly country. From there, the Tisza is, in fact, a recipient of the single tributaries. The shape of the watershed area is unfavourable, short and broad. The slope of mountain- and hill-sides is very steep, the tributaries reach the main river after a comparatively short course, the waves of floods accumulate. The rainiest part is the territory of the Carpathian Ukraine where the May and June showers and October rains are frequent. The fall of the main basin is from the river-head till the mouth of the Szamos 584 cm/km on the average; that in the Hungarian stretch is, however, extremely small, between 10 and 1 cm/km. At floods, the fall of water suddenly grows in the front of the flood-passing, manifested very strongly in the increased speed of flowing (Fig. 1).

From the watershed area of the Upper-Tisza waters of violent water-course rush down, being able to sudden inundations, and reaching the flatland that is nearly without any fall, they accumulate. The show in the mountains thaws at the feet of mountains at the end of March and in April, and on the hills already in the first part of April. From that part of the watershed area of the Tisza generally three major flood-waves start:

— the late-winter and spring floods originating from the thaw of the snow-cover of the flatland and hill-country (late February, March);
— the spring-flood resulting from the thaw of the snow-cover of mountains (April, May) and mainly from the showers of the territory of the Carpathian Ukraine (May, June);
— the autumn- or leaf-covered flood resulting from the summer and autumn rainfalls and corresponding to precipitation maxima that come mostly not in a striking way.

From the middle of Summer till the middle of Autumn a typical "small-water period" develops. The Tisza is, in most part of its course and according to its general character, a flatland river. Its water output and water movement are, however, determined first of all by the peripheral mountains, and the extent of the specific water transport by the precipitation that fell from Autumn till Spring and accumulated in the shape of snow.

The Upper-Tisza and its tributaries filled up the valleys with stone, river-gravels, the gravel-ground of the river-bed being 5 to 10 m thick or even a thicker layer. Below Tiszabecs the gravel is replaced by coarse-grained sand, then the river-bed becomes increasingly siltier till the mouth of the Szamos. The Szamos again carries coarse-grained sand into the bed of the Tisza, forming deposits in form of sandbanks between Vásárosnamény and Tiszakecel.

The medium speeds of the bed can be put at 0.4 m/sec, that of the current at 0.6 m/sec. In case of large water at Tiszabecs the speed of the current attains 4 m/sec and, similarly in case of large water, at Vásárosnamény the speed of flow can be esteemed 2.5 m/sec.

The quality of Tisza-water in the segment of the national boundary (river-km 757) is very favourable. It is characterized by a low oxygen consumption, and the low value of mineral-matter content and ammonium. The quantity of direct pollution of water-course till Szolnok is not considerable, only the affluents do exert a loading effect.

At floods the suspended matter content is very high. It is characteristic of its alluvial transport that it can drift at Máramarossziget still large blocks of stone, at Bökény stones as big as a fist and head. Below Mezővár it already drops even a pebble, its sand, too, becomes finer and finer, and at Vásárosnamény its alluvium is already mostly fine silt. Its dominant water type contains calcium-hydrogen-carbonate. The quantity of the Tisza water is influenced by the water-composition of its major tributaries, as well, mainly in the period of floods.

The major tributaries of the Upper-Tisza are the Szamos, Bodrog, and Sajó rivers.

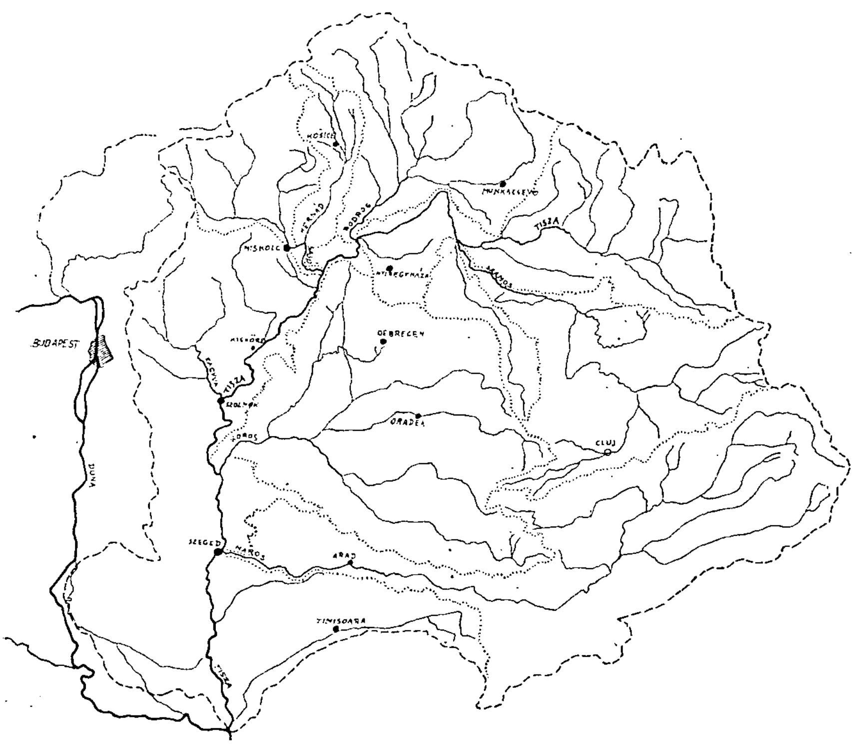

Fig. 1. Map of the Tisza and its tributaries

The watershed area of the Szamos is 15,882 sq.km, mostly medium and low mountains, in a smaller part a flat region. The formation of sudden floods is promoted by its impermeable rocks. Summer showers are frequent, larger autumn rains occur but rarer.

The dominant type of Szamos-water at small water output contains calcium-sodium hydrogencarbonate, at large water output calcium-magnesium hydrogen-carbonate. Its suspended matter content is high mainly at the time of a flood.

The watershed area of the Bodrog is 13,579 sq.km. it is lying in a region with not too high mountains, its shape is unfavourable. Because of the semipermeable surface and the rich enough precipitation, the river carries a considerable water mass into the Tisza.

In a fan-like valley-system the waters gushing down with high speed from the mountains accumulate in the flatland as the fall is only 3 cm/km there. Its rain-induced flood-waves get to the mouth 3—4 days later, as compared to the flood-waves of similar origin in the Tisza. The water of the Bodrog may be characterized with its small oxygen content. It is polluted according to the indices of the oxygen household, as well as on the basis of the quantity of ammonium. Its suspended matter content, is but a little higher if the water output increased. Its dominant water type contains at small water calcium-magnesium hydrogencarbonate, at medium and large water calcium hydrogencarbonate.

The common watershed area of the Sajó and Hernád is 12,708 sq.km, it is fan-like, keeping its mountainous character as far as the mouth of these river. Its fall is great: 44 cm/km even in its lowest region. The flood-waves get, therefore, ahead of those in the Tisza 4—5 days.

From its valleys of loose soil the flooding water carries with itself much alluvium. The total hardness and total dissolved matter content of these waters increase along the water-course. Their suspended matter content is very high at flood but it is low at small water. Their dominant water-type contains at small and medium water outputs calcium-magnesium hydrogencarbonate-sulphate, at large water calcium hydrogencarbonate.

Artificial effects

Damming

The regulation of the changeable water movements of the natural water-courses, the utilization of the available supply of water as properly as possible, the formation of a satisfactory water-way can be assured by means of building river barrages.

The artificial formation of a comparatively lasting water-level, the damming, influences both the chemical composition and the biological conditions of the Tisza considerably. As a result of that, the water mass of the stretch dammed inreases, the speed of water-course decreases. It plays an essential part in forming the conditions of suspended matter, increasing the transparency of water, and shifting the percentages of the equivalents of chemical components, *i. e.*, in changing the water-type.

To damming, the living beings do respond sensitively, as well. In its plankton some micro-organisms multiplied that had occurred but rarely so far or had even been unknown.

In the small-water period that is so characteristic of the Tisza, as a result of damming the backwater character becomes manifest both in chemical and biological relations (Ádámosi *et al.* 1974, Hamar 1975, Végvári 1975).

Storing

Storing can be placed among the artificial interventions having an influence on water quality, putting forward some effects that were insignificant for the freshwater. The formation of the chemical composition and biological state of the water stored depends in high degree upon the water-depth of the reservoir, the organic-matter loading, therefore upon the quantity of the land vegetation that remained in the storing space, upon the organic-matter and mineral-matter content of the surface soil, as well as upon the floating matter carried by the supplying river. It depends, overmore, upon the size of the water surface, the temperature, the evaporation and concentration induced by these.

The living beings of water can be determined to a great extent by the rich micro- and macroflora, as well as the fauna of the dead arms and borrowing-pits in the bed of the reservoir to be formed.

There appear, as new factors, the effect of the wind and the size of waves brought about by that, as well, that can exert an influence, apart from inundations and the living beings in water, on the formation of the suspended matter content and the oxygen circulation, too.

Urbanization, industrial and agricultural activity

The water-quality is also considerably influenced by the waste-waters, induced by the communal, industrial, and agricultural activities, carried without cleaning or after an inadequate purification into the living freshwater, as well as by the matters getting into the water or applied without due foresight. The waste-waters of organic-matter content (faeces, industrial refuse from sugar-works, paper-mills, etc.) may cause directly a rise in the saprobity degree of water, indirectly in the trophity degree of it; the waste-waters including chemical fertilizers may cause directly a rise in the trophity degree of water, indirectly in the saprobity degree of it; and the waste-waters containing poisoning materials (heavy-metal salts, cyanides, pesticides, etc.) may cause a rise in the toxicity degree of water.

A considerable mass of cooling water of higher temperature, removed from the freshwater and getting back there after being emolliated, results in heat-pollution and in changing the quantitative conditions of the salt content.

Extraordinary pollutions

It has been proved by the experiences of the last years both in this country and abroad, how great dangers can be induced by some extraordinary pollutions originating from traffic and water-way accidents, operating troubles, failures of cables crossing a freshwater, that passing down the water-course as waste-water waves, are changing its chemical composition, damaging its natural history (Hamar 1970/71). The effects of the waste-water waves may bring about temporary changes in a freshwater (Uherkovich 1971) but the changes induced by them in the reservoir are considerably more dangerous and enduring.

A forecast of the hydroecological changes in the future reservoirs can only be achieved by recognizing the regularities of nature, and evaluating the artificial fish-ponds in an up-to-date way, supporting that with the results of investigations.

The more and more increasing water demand of the society can be satisfied in both quantitative and qualitative relations by taking advantage of the natural opportunity and revealing the causes of the unfavourable effects and bringing them to an end.

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WATER MOTION IN THE RIVER TISZA AND ITS CONNECTION WITH THE SUSPENDED MATTER CONTENT IN 1974

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(Received 30 June, 1975)

Abstract

The paper is dealing with characterizing the water motion in the Tisza that is very extreme as a result of the extraordinary weather in 1974, it is treating of the artifical interventions and effects, too, as well as of the formation of the suspended matter content.

Introduction

In 1974 the very extreme water motion, brought about by the extraordinary weather, was characteristic of the Tisza. The chemical composition of, and the biological changes in the Tisza reaches investigated by us (Tiszacsege—Tiszaroff) were determined mainly by the quantity and origin of the precipitation inducing inundations, the quality and quantity rations of the water masses coming from the watershed area, as well as by the artifical interventions (BANCSI 1975, HAMAR 1975).

Material and method

In 1974, we investigated the middle, 70 km long reaches of the Tisza regularly, at five sampling points, with fortnightly, but in some cases at the Kisköre water barrage with weekly frequency.

The measurement of the suspended matter content was carried out on every occasion by filtering the 500 ml original water sample by means of a Sartorius SM 0.45 μ membrane ultrafilter, and weighing it, after being dried, with an analytic balance of four figure accuracy.

Characterization of the water motion of the Tisza in 1974

Because of the rainless period at the end of 1973, there could not be formed any considerable snow-cover on the watershed areas. The degree of inundation at the end of the Winter and in Spring was determined by this condition, and it was of very slight course.

The postponement of spring-flood may be attributed to similar causes, as well. The formation of the "spring-flood" was determined by the sudden thaw of the mass of precipitation accumulated in the higher mountains in the form of snow (April—

May) and the water quantity of showers pouring on the watershed area (May—June) (VÉGVÁRI 1975).

From the thaw of snow-cover a negligibly water quantity has resulted. Thus the spring-flood was postponed in time, as a result of the precipitation of very large quantity that poured on the watershed areas of the Upper-Tisza and Szamos from the middle of May till the end of June. The water coming from the watershed area of the Upper-Tisza culminated at Dombrád with 2700 cc.m/sec water output. The maximum water output of the Szamos at Csenger was 1900 cc.m/sec. The Tisza flood-wave was followed by that of the Bodrog one day later, it culminated at Felsőberecki with 660 cc.m/sec. The water output of the Sajó and Hernád did not play any part at the summer inundation. The flood-wave of Tisza culminated at Kisköre with 2670 cc.m/sec water output on yune the 26th.

There poured an extremely large mass of precipitation on the watershed area of the Upper-Tisza, Szamos, Bodrog, Sajó and Hernád from the beginning of October till the end of November. The autumn-flood or "flood with leaves" (VÉGVÁRI 1975) that appeared in the earlier years, and according to the literary data, mostly levelled, not in a remarkable way, meant in 1974 the formation and passing of the largest flood-wave both in the Tisza and in some of its tributaries. At the autumn flood the Tisza culminated at Dombrád with 1850 cc.m/sec, in the Szamos at Csenger with 850 cc.m/sec water output, there arrived therefore much less water mass than in Summer from the watershed areas of both rivers. As a result of the extra-ordinary rains, a considerable flood started from the watershed areas of the Bodrog, Sajó and Hernád. The Bodrog culminated at Felsőberecki with 1050 cc.m/sec water output. The water output of the Sajó at Felsőzsolca, on October the 24th, reached 565 cc.m/sec, that of Hernád at Gesztely 520 cc.m/sec, and at the mouth they preceded the flood-wave of the Tisza, that culminated at Kisköre with 2960 cc.m/sec water output, about 5 to 6 days.

Owing to the postponement of spring-flood and the larger than usual autumn inundation, the „small-water period" that is characteristic of the Tisza, could only be formed in the month of August.

Characterization of the effect of damming up the water in the area of Kisköre River Barrage

The damming of river bed may exert a considerable influence on the chemical composition of, and biological changes in the water of Tisza (ÁDÁMOSI *et al.* 1973, BANCSI 1975, HAMAR 1975).

In 1974, the way of operating the Kisköre River Barrage was determined by the smaller or larger flood-waves following one another. As depending on the degree of floods and the time of their passing, there was a damming for 260 dasy and the water flowed without any damming for 105 days in the course of the year. Between February 10 and 14 and February 21 and 25, for four days each, from June 5 till July 20 for 45 days, between July 25 and August 3 for 9 days, and between October 14 and November 26 for 42 days there was no damming. It follows from the foregoing unequivocally that because of the extremely inordinate water motion the damming could not prove so effectual as observed in the small-water periods of the year 1973 (ÁDÁMOSI *et al.* 1973). It was remarkable that even during the comparatively short periods between floods we did notice certain characteristics of the formation of backwaters, like e. g., the increase in magnesium content, the decrease in the number of bacteria, the appearance of phytoplanktons of backwater type, the establishment of filamentous green algae on the stony banks.

Change in the suspended matter content and its connection with the characteristic of water outputs and watershed areas

In case of different water outputs, the suspended matter content of the Tisza has changed in wide intervals (5 to 555 mg/l). The total suspended material and the water output belonging to it have shown, in the first approximation, no unequivocal connection.

In case of identical water outputs, in different times, we have measured values very different from one another, as well; on the other hand, there have often belonged different water outputs to a similar quantity of suspended matter. Taking into consideration, apart from the absolute quantities, also the character of the change in water, then we may establish the following:

The maximum value of the suspended material always preceded the culmination of flood-wave, then still before culminating it considerably decreased and, till passing of the flood-wave, anyway with smaller of larger fluctuations, it preserved an approximately standing value.

A similar situation has evolved in case of more flood-waves within a single inundation, as well (Fig. 1).

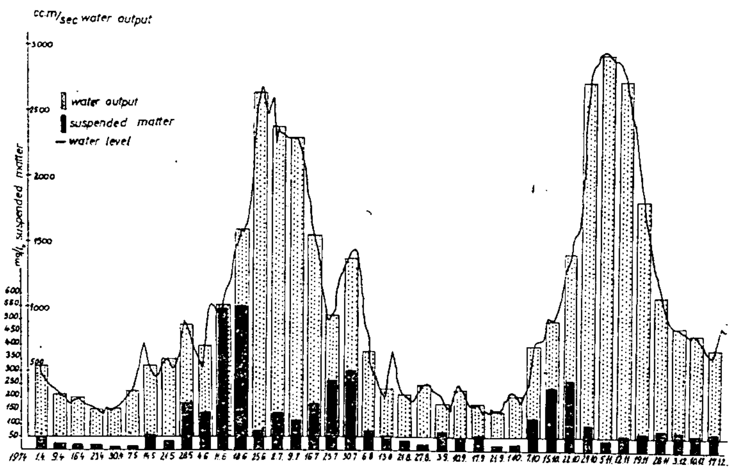

Fig. 1: Formation of the water-level, water output and suspended matter in the Tisza profile at Kisköre in 1974

Comparing the floods in Summer and Autumn we have learned that the maxima of the suspended matter measured on the occasion of the autumn flood-wave that culminated with a larger water output were essentially smaller than those of the summer flood. Investigating the conditions of the formation of both floods, we have established the following differences:

The spring-flood took place first of all as a result of the precipitation of very large mass poured on the watershed areas of the Upper-Tisza and Szamos. Most part of its water-mass was formed by the water-mass of the Tisza and Szamos, transporting an extremely large quantity of suspended matter. As a result of that (as shown by the data of the Water Management of the Upper-Tisza Region, Inspectorate of Water Quality, from 1974), the suspended matter content was 1475 mg/l at Tokaj, on June the 16th, 555 mg/l at Kisköre on June the 18th.

At the autumn flood, there arrived a smaller water quantity than in Summer both from the watershed area of the Tisza and from that of the Szamos. In that period, however, the Bodrog and Sajó transported a considerable water mass, as well, and they carried together a larger quantity of suspended matter than the Tisza. The Bodrog contained on the 8th of October 634 mg/l, and before the mouth of Sajó, on the 17th of October 546 mg/l matter in suspension (data of the Water Management of the Upper-Tisza Region, Inspectorate of Water Quality, from 1974).

The mass of the matter in suspension of the smaller suspended load of the Upper-Tisza and Szamos measured at Kisköre remained — as a result of the temporal postponement of the flood-waves of the Bodrog and Sajó — smaller (270 mg/l on the 22nd of October), in spite of the flood being larger than that in Summer.

It was proved by the results of the investigation in 1974 that, on the occasion of flood, the momentary suspended matter content is depending not only upon the water output but, to a considerable extent, upon the character of the change in water and the conditions of the formation of flood-waves, as well.

We have established that the suspended matter content is an essential parameter from hydrochemical and hydrobiological points of view, too, exerting a strong influence on the total iron content, the calcium and magnesium content, the chemical oxygen demand (C. O. D.), the total phosphorus and total nitrogen content, as well as on the species and individual-number compostion of the aquatic flora and fauna, in the same way.

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Tiscia (Szeged) Vol. XI, pp. 21—25 (1976)

HYDROCHEMICAL CONDITIONS OF THE RIVER TISZA 1. MINERAL MATTER CONTENT AND ION-DYNAMISM ON THE BASIS OF THE INVESTIGATIONS IN 1973 AND 1974

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Abstract

The paper is dealing with the change in the mineral matter content of the Tisza. The changes in the water type, that may be interpreted as an effect of damming and concentration, alow an inference to the Tisza having a natural disposition to change the type.

Introduction

The mineral composition of the Tisza was determined under natural conditions first of all by the geochemical properties of the watershed area of the river. This establishment was unequivocally proved by the investigation of the flood-waves passed in 1974. In the time of flood, the types and quantitative proportions of the waters coming from the watershed areas are dominating in the formation of the mineral matter content of the Tisza flowing without being dammed up, while at the floods passing the water coming back from the flood-plain and the effect of damming, as well, became influencing factors.

Material and method

We have investigated a 70 km stretch of the Middle Tisza Region at five sampling points, with a fortnightly, resp. weekly frequency. For the chemical investigations we took a 5 l dipped-out sample. The determinations were carried out with the „VITUKI" methods of water investigation (1970) and on the basis of Felföldy's work (1970).

Mineral matter content of the Tisza

As a first step, we have investigated how the concentrations of cations (sodium, calcium, magnesium) respond to the changes in water output. It may be established on the basis of the results of the water-sample investigations that the sodium content decreased at the increase of water output and increased in case of a decreasing output (Fig. 1).

The shift of the calcium-magnesium rate met with at small water output, in the late summer — autumn period of 1973 (ÁDÁMOSI *et al.* 1973), in 1974 did not appear, in a striking way, just owing to the flood-waves following one another. In Fig. 2, anyway, it may be observed well that at the small water outputs lasting for a comparatively short time between the times of floods, the increase in magnesium concentration began, without reaching the calcium concentration. By comparing the calcium and

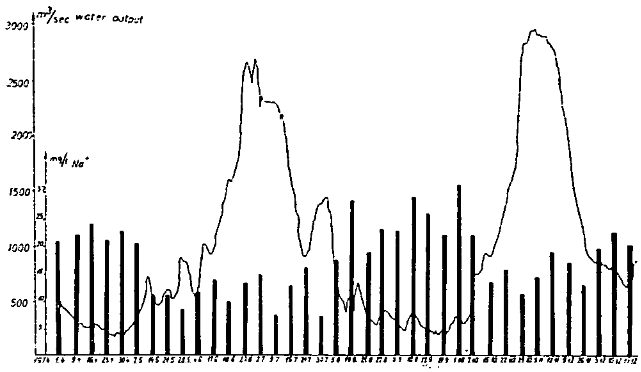

Fig. 1. Change in Na+content and water output in the Kisköre profile in 1974.

magnesium values measured at Kisköre in 1973 and 1974, as well as the water outputs belonging to these, it could be demonstrated that a considerable increase in the magnesium concentration, as well as a decrease in the calcium content, that is to say, a change in the water type can or did take place till 500 cc.m/sec. water output, as a function of the permanence of water output and as a result of damming. The probability of that, however, decreases more and more together with an increase in the water output because in case of a larger water output also its disposition to be durable increase considerably (Fig. 3).

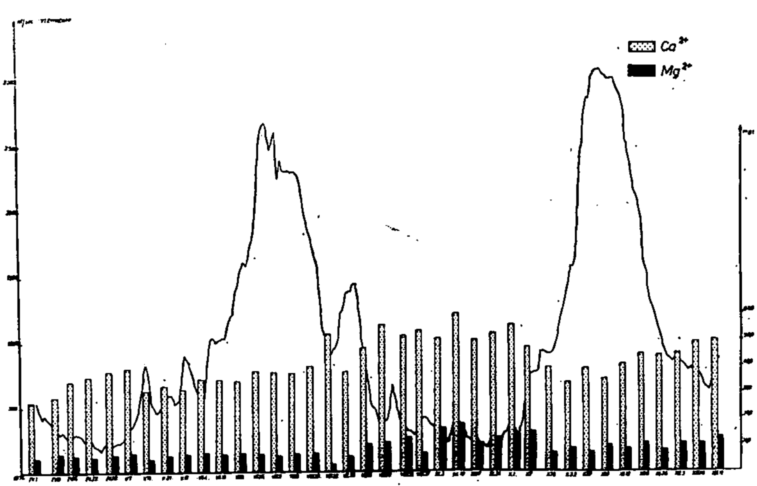

Fig. 2. Change in Ca^{2+} and Mg^{2+} content and water output in the Kisköre profile in 1974

The conductibility that considerably depends upon the mineral matter content of the water increased generally with a decrease in water output, the degree of that was, however, determined by the simultaneous effect of several parameters (temperature, lastingness of the water output, damming up, etc.). The formation of the ion-concentration in the dammed water, as well as the possible changes in types, will be determined first of all by the increase in water surface, the rise in the water temperature, the concentration followed as a result of the artificial heat pollution. It became, therefore, necessary to investigate the quantitative relations of cations and anions, taken as a function of a change in conductivity instead of that in water output.

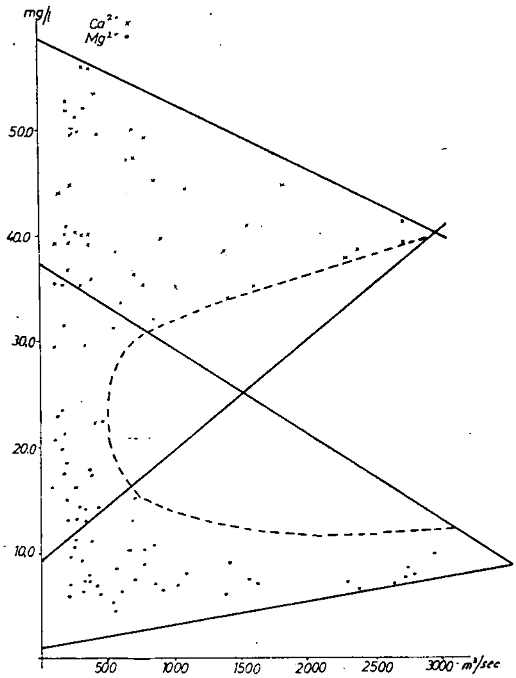

Fig. 3. Change in Ca^{2+} and Mg^{2+} content, taken as a function of the water output, on the basis of data from 1973 and 1974

The conductivity of the clear water of natural flow (without damming) — owing to the comparatively small water surface, a low evaporation, and a continuous change in water mass — did generally not rise over the 500 micro-Siemens value; the halobity of water was beta-alpha oligohalobic, its type calcium-hydrocarbonic.

Our systematic investigations in 1973 and 1974 produced some results from which a conclusion may be drawn concerning the disposition of the Tisza to change the water type. The storage-induced concentration conduces to a considerable rise in conductivity. The rise in conductivity is connected with a decrease in calcium and hydrocarbonate that determine the water type of river Tisza, and an increase in some ions that so far dominated but a little or not at all, like magnesium, sodium, chloride and sulphate, resulting from time to time in changes in the water type (Fig. 4).

Apart from the changes in type (calcium-magnesium-hydrocarbonate, and later magnesium-hydrocarbonate-sulphate types), the increase in the sodium and chloride concentration, influencing the quality of irrigating water, calls the attention to one of the natural sources of danger in connection with the storage of Tisza water (Fig. 5).

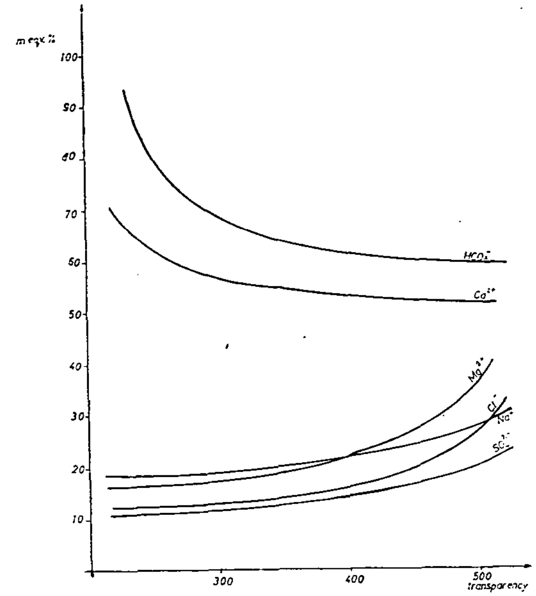

Fig. 4. Direction of the Tisza disposition to change the water types, taken as a function of the meq. percentual rates of ions and of conductivity, on the basis of data from 1973 and 1974

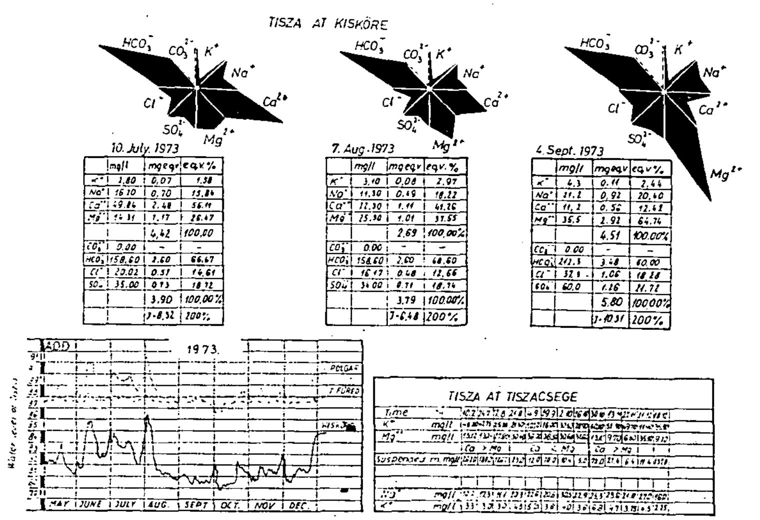

Fig. 5. Change in the water type of the Tisza in 1973, in a period of permanent little water, as a result of damming. In ÁDÁMOSI *et al.* 1974)

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HYDROCHEMICAL CONDITIONS OF THE RIVER TISZA 2. SEASONAL DYNAMISM OF THE OXYGEN HOUSEHOLD AND NITROGEN-PHOSPHORUS FORMS

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Abstract

The paper is dealing with the oxygen household and plant food circulation of the Tisza-stretch dammed up between Tiszacsege and Tiszaroff (river-km 456—380). It is treating of these factors — that are important in respect of the water quality of the future Kisköre reservoir — with a view to saprobity and trophity.

Introduction

In the Middle-Tisza Region of Hungary the building of a shallow-water reservoir is going on. At present the damming of the river-bed is taking place, the area will be filled up in 1978. For storing the water of the Tisza is used. The previous systematic chemical and biological investigation of that is a fundamental requirement from the point of view of protecting the water quality of the future Kisköre Reservoir.

The water quality of reservoirs is equally influenced, apart from the factors that can be determined previously and measured comparatively well, by the oxygen conditions, too, indicated with much less safety and connected with the activity of living beings. It was based on this reasoning that we carried out the investigations of the Tisza giving water supply to the future Kisköre Reservoir.

The number of the hydrochemical investigations dealing with the Tisza is small. PAPP (1965) is publishing data concerning the Tisza and its tributaries. SZÉPFALUSI (1970—1971) is dealing, as well, with the hydrochemical conditions of the Tisza-stretch between Csongrád and Szeged and the tributaries.

Material and method

Our investigations were performed in 1974, in the river-stretch between Tiszacsege and Tiszaroff, from five sampling points, with fortnightly frequency (Tiszacsege river-km 456, Tiszafüred river-km 433, Tiszaderzs river-km 415, Kisköre river-km 404, Tiszaroff river-km 380). But from the Kisköre profile we took samples with weekly frequency.

For chemical investigations we dipped out a 5 l sample. For determining the dissolved oxygen and free carbon dioxide we used a special sampler.

Our analyses were carried out on the basis of the "COMECON" Unitary water-research methods, issued by the "VITUKI" (1970) and Felföldy's lecture notes: Biological Water Qualification (1974).

The mineral matter circulation in the Tisza is treated of by Végvári's paper (1975). In addition to the chemical investigations, we have performed biological studies, as well (BANCSI 1975, HAMAR 1975)

Evaluation of results

The increase in the oxygen content of waters is induced by the amount of atmospheric oxygen getting in by means of the surface diffusion and owing to the water movement, as well as by that of molecular oxygen released in the course of the photosynthesis of the plants of chlorophyll content. On the other hand, its decrease is caused by the respiration of the vegetable and animal organisms, the decomposition of organic matters, the rise in water temperature, etc. At river waters, the oxygen supply is generally favourable, because of the intensive water movements.

The formation of the *dissolved oxygen content* of the Tisza was determined by the changes in the atmospheric oxygen, got in in the course of the water movement, and the changes in water temperature. The high suspended matter content, namely, resulting from the floods of 1974, impeded the photosynthesis, and the flood-waves, following one another, produced a considerable water movement, mixing, and whirling.

It can be established from the results of the investigations in 1974 that both the dissolved oxygen content and the oxygen saturation were greatest in the Winter period, in Spring they decreased, and the lowest values were measured in the summer period. In Autumn, a rise followed again, but its value did not reach the winter maxima.

The annual average value of the dissolved oxygen was 9.32 mg/l, and the oxygen saturation was 81.5 per cent that can be considered as suitable.

The quantitative relations of the dissolved oxygen and free carbon-dioxide contents of backwaters are treated of in connection with one another. The results are brought into connection with the activity of autotrophic and heterotrophic living beings (DÉVAI *et al.* 1969—1970).

The floods following one another in 1974, engendered unfavourable light conditions. Therefore, the photosynthesis of a negligible degree did not influence either the amount of dissolved oxygen or that of free carbon dioxide to such an extent that we could speak there either of a daily rhythm or of any other connection that could be demonstrated.

The *changes in the free carbon dioxide* were determined first of all by the composition of the waters coming from the reservoirs, their quantitative proportions, respectively the concentration of the components (hydrogencarbonate, calcium, magnesium) influencing the amount of the free carbon dioxide.

In the period passed from January till the beginning of the spring-flood, the free carbon dioxide content was 2.67 mg/l, as an average of 60 samples. This rose, in the period of the spring- and autumn-floods passing, about 2.5-fold, to 6.57 mg/l, as an average of 84 samples.

Of the carbonate and hydrogencarbonate conditions in the waters of the Tisza some data were published by VÉGVÁRI (1975).

The degree of the chemical oxygen requirement measured with *acid potassium* permanganate (C. O. D. Mn) and *potassium dichromate* (C. O. D. Cr) was determined by the organic component of the suspended matter transported by the flood-waves following one another, the organic-matter amount of the water reflowing from the flood-plain, the effect of the tributaries loaded with waste-water, and the self-purification of the Tisza.

On the occasion of floods, the formation of the amount of the chemical oxygen requirement was influenced first of all by the suspended matter content. After the flood passing, however, there was prevailing rather the effect of other factors (tributaries, flood-plain, waste-waters, etc.).

The Kisköre Reservoir will be filled up with Tisza-water. The effect of the chemical oxygen requirement of the organic matter carried by the feed-water upon the water quality of the reservoir is, therefore, to be taken into consideration.

On the basis of the investigations in 1974, taking into account the average value of the chemical oxygen requirement (6.27 mg/l), and the average value of the dissolved — oxigen content (9,32 mg/l), as well as the water mass to be stored in the reservoir (300 million cc.m), it can be calculated that after the oxidation of the organic matter carried by the water supply, 4.7 mg/l dissolved oxygen still remains in the water if we apply the quantities calculated to the reservoir as a static model. It appears from the data that the organic-matter loading of the feed-water does not mean any danger to the water quality of the reservoir, that is to say, it hasn't any considerable influence to the saprobity of water.

In the life of the water ecosystems, parallel with the oxygen conditions, their vegetable food supply, too, has an important part. Eutrophication, this slow biological reaction that means the aging of lakes, the gradual deterioration of water quality (FELFÖLDY 1974), may take place in case of artificial lakes or ponds at a much quicker pace. In that process, the productivity of waters has a very important part, for the forecast of which it is necessary to know the nitrogen and phosphorus forms coming by means of the water supply.

On the course of our investigations, the determination of the following phosphorus forms was carried out:

— dissolved non-reactive phosphorus (sum of inorganic condensed phosphates and dissolved organic phosphorus),
— dissolved reactive phosphorus (dissolved orthophosphates),
— sestonic phosphorus formed (any phosphorus bound to solid particles, essentially the phosphorus content of the suspended matter, quite apart from the fact if it is biologically active or inactive).

There is a well-perceptible connection between the biologically available total phosphorus and trophity. The total phosphorus content of the settled deep lake water means essentially the biologically accessible total phosphorus, while in shallow lakes it is disturbed by the inorganic sestonic phosphorus forms stirred up from the bottom sediment (FELFÖLDY 1974).

In case of the Tisza water, some other disturbing elements, too, do play a part.

— In a lasting small-water period, the value of total phosphorus, measured in the river-stretch dammed up, approaches the concentration of the biologically accessible total phosphorus mostly.
— At the beginning of the flood the phosphorus bound to the suspended matter considerably increases the amount of the phosphorus formed (Fig. 1).
— The amount of the organic phosphorus formed, found in the living organisms at flood, may be neglected because of the small number of these.
— The ratio of suspended matter and the phosphorus bound to that is very different;it depends on the surface and weight of the suspended matter, the amount of the organic waste. the geochemical properties of the watershed area, the quantitative conditions of the waters coming from there, etc.
— Together with the suspended matter content decreasing before the culmination of the flood-wave, the amount of the phosphorus formed, too, decreases; at the flood passing, however, the organic phosphorus built in the

plankton organisms of the water reflowing from the flood-plain results in a repeated increase in the amount of phosphorus formed.

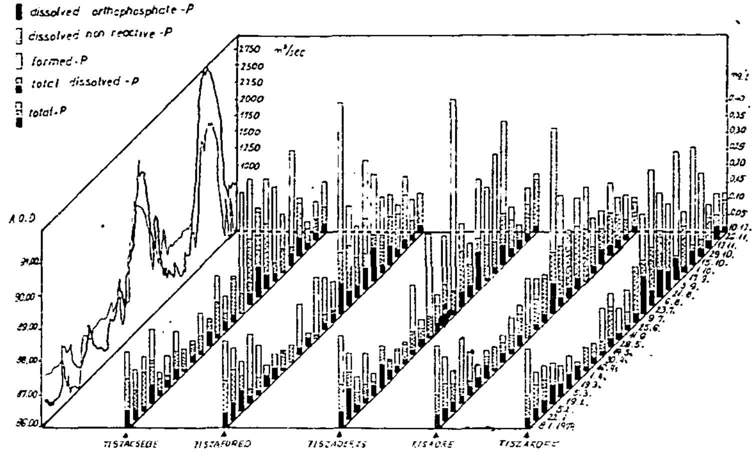

Fig. 1. Formation of the phosphorus forms of the Tisza-stretch investigated

Balancing the disturbing effects described above, at investigating the trophity of feed-water, we have taken the concentration values of the dissolved orthophosphate phosphorus available for the autotrophic organisms, for our basis.

The dissolved orthophosphate phosphorus content of the Tisza at Tiszacsege from January 8th till January 16th was 0.025 mg/l, its maximum value being 0.090 mg/l. At Tiszafüred we measured generally higher values. As approaching to Kisköre, these values have gradually decreased but from the sampling point below the river barrage (Tiszaroff) they rose again (Fig. 1).

On the basis of 25 samples, the average value of the dissolved orthophosphate phosphorus is:

Sampling point	*Average mg/l*
Tiszacsege	0.028
Tiszafüred	0.033
Tiszaderzs	0.031
Kisköre	0.027
Tiszaroff	0.035

The dissolved orthophosphate concentration was not influenced considerably by the small-water period, the minor flood-waves, and the beginning of flood.

At passing of the major flood-waves, however, we experienced a considerable increase, appearing at Tiszacsege still less but at Tiszafüred and Tiszaderzs to a greater extent. The results are referring to that the orthophosphate content of the water reflowing from the flood-plain — that may have originated from the mineralization of the organic matter existing there (VÉGVÁRI, 1975) — has played a part in increasing the concentration. That is proved also by the maxima measured at Tiszafüred and Tiszaderzs (0.103 mg/l; 0.115 mg/l).

The lakes may be considered, on the basis of the 20—40 mg/cc.m total phosphorus, as meso-eutrophic (FELFÖLDY 1974). The average value of the dissolved orthophosphate content of the Tisza is 28 mg/cc.m. According to FELFÖLDY (1974), however, we have to regard as the degree of eutrophication of the lake not the average but the most eutrophic state of that. In case of the Tisza, this value means 90 mg/cc.m dissolved orthophosphate phosphorus, on the basis of which the water can be considered as eupolytrophic.

Taking into consideration 60 per cent of the total phosphorus of the Tisza-water (leaving 40 p. c. out of consideration due to the disturbing effects), then we had to reckon with 111 mg/cc.m total phosphorus on the average or, in respect of the highest concentration, with 232 mg/cc.m of that. This would mean in both cases a polytrophic water.

R. A. VOLLENWEIDER (1968, in: HANNAN et YOUNG 1974) established that the 20 mg/cc.m total phosphorus content may be the critical concentration of algal blooms.

We are reminded by the comparison of results to reckon in case of the Kisköre Reservoir with the danger of eutrophication because of the high phosphorus content of the river.

The other vegetable food showing the degree of trophity is *nitrogen*, in the circulation of which the aquatic living world plays a determinative part. In some lakes, from time to time, nitrogen proved to be an impeding factor of photosynthesis or production (FELFÖLDY 1974).

As investigating the water of the Tisza, we have carried out the determination of the following nitrogen forms:

— nitrate nitrogen	(1)
— nitrite nitrogen	(2)
— ammonia-nitrogen	(3)
— ammonium-nitrogen	(4)
— nitrogen of organic bond	(5).

The sum of the concentration of forms 1, 2, 3, 4 gives the mineral nitrogen (nitrogen of inorganic bond), the some of the amount of the five forms the total nitrogen. The mineral nitrogen is an important factor at evaluating trophity, and the nitrogen of organic bond plays a part at establising the degree of saprobity.

In respect of eutrophization, 300 mg/cc.m mineral nitrogen is described as a dangerous threshold value (VOLLENWIEDER 1968, FELFÖLDI—TÓTH 1970). The inorganic nitrogen content of the water of the Tisza is averagely 2200 mg/cc.m, its maxima are 4598 mg/cc.m. On the basis of these data it is qualified as polytrophic.

It can be observed from the results of the investigations in 1974 that in small-water periods the nitrogen content of inorganic bond is very high, on the average 3—4 mg/l (Fig. 2).

At the beginning of the summer flood — supposedly as a result of dilution — we experienced a slight decrease (1.7—2.2 mg/l). At inundating the flood-plain, the developing micro-and macro-vegetation consumed the mineral nitrogen almost completely (VÉGVÁRI 1975). In this way, at the flood passing, the water reflowing from the flood-plain considerably reduced the mineral nitrogen concentration of the Ti sza (0.8—1.0 mg/l).

At the autumn flood passing, the decrease in the amount of mineral nitrogen was of much less degree because of the (due to the season) slower mineralization and the building in being more equalized.

That is shown by the slower development and smaller number of the stand of phyto- and zooplankton than those in Summer, as well as by the very high bacterial count, too (HAMAR 1975, BANCSI 1975).

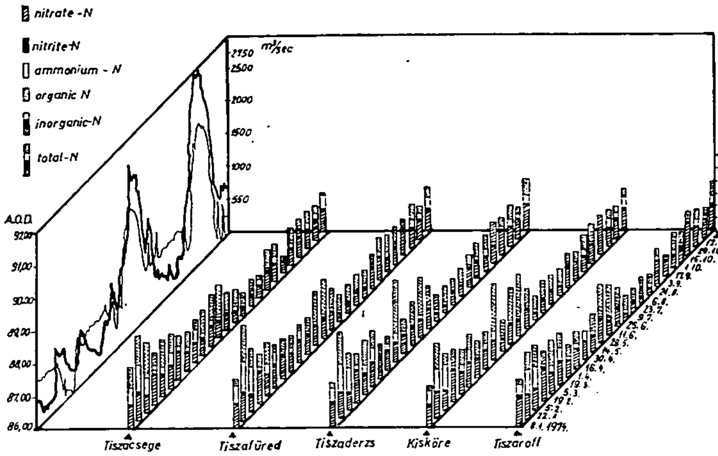

Fig. 2. Formation of the nitrogen forms of the Tisza-stretch investigated

The amount of the nitrogen of inorganic bond in the water of the Tisza is considerably influenced by the degree and duration of floods, by length of the small-water periods and quality of the water reflowing from the flood-plain. In annual relations, however, the content of mineral nitrogen of the water flowing into the stretch investigated by us and leaving that does not change considerably (Fig. 2).

At evaluating trophity, resp. eutrophication, the considerable vegetable foods, like phosphorus and nitrogen in the feed-water of the Kisköre Reservoir, can be found in a very high quantity in the Tisza-water. Their concentration is much above the dangerous threshold value. On the basis of the literary data concerning deep lakes, the water of the Tisza can be qualified as polytrophic in respect both of phosphorus and of nitrogen.

Summing up, we may establish that the oxygen household of the water of the Tisza is suitable from the point of view of the water quality in the Kisköre Reservoir. The formation of the factors determining the plant food circulation, however, calls our attention to the danger of eutrophication.

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Tiscia (Szeged) Vol. XI, pp. 34—39 (1976)

SOME RESULTS OF THE CHEMICAL INVESTIGATIONS OF THE RIVER TISZA IN 1974

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Abstract

The paper is evaluating some water quality components of the supplying water current from the point of view of the future Kisköre Reservoir, supposing that till 1978 no important changes occur, except for the extraordinary water pollutions.

In addition to reporting on the connections discovered on the basis of the results of investigations carried out for a rather long period (about one and half years), we are dealing also with the problems of homogeneity, the optimum sampling point, and frequency.

Introduction

One of the determinants of the water quality in the future reservoir will be undoubtedly the supplying water current. We are attempting, therefore, by evaluating the present data appropriately, to describe the physical and chemical processes that take place in the river reaches investigated and may in the future exert a decisive influence on the water quality in the Tisza and the Reservoir.

The chemical and biological changes induced by the Kisköre damming up in the middle Tisza region since April 1973 (ÁDÁMOSI *et al.* 1974), have raised, as compared to the investigations in the former decades, more problems and it will be an interesting task of the next years to reply to these.

Characterization of the area investigated
Material and method

The length of the Tisza region investigated by us is about 70 km. Samplings were carried out from the current-line of the river between Tiszacsege and Tiszaroff (Fig. 1), at Kisköre weekly, at Tiszacseg, Tiszafüred, Tiszaderzs, and Tiszaroff fortnightly.

There are considerable differences to be found in the structure of river bed in some places. The profile of the sampling point at Tiszacsege is characterized by a smaller depth and larger breadth, while above Kisköre we may notice a larger depth and smaller breadth in case of identical water outputs, as depended on the damming up, as well.

We have sampled at the limit of transparency, but for investigating the stratification we have taken samples by means of a semi-rotary pump from various depths. Transparency was measured with SECCHI's disk.

The chemical investigations were carried out with the Uniform Methods of Water Investigation of COMECON (typ. Sartorius SM 11 306). The elaboration took place on the day of sampling.

The water output could be determined at several points after surveying the river-bed with speeds measured in various depths. The water quantity flow through the constructive works was always at our disposal.

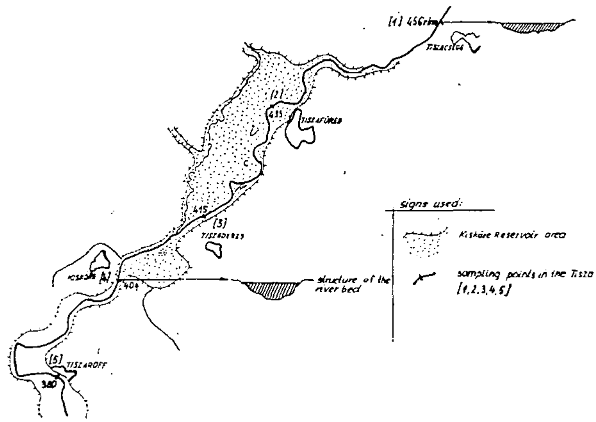

Fig. 1. Sampling points at the Tisza and the Kisköre Reservoir (schemetic plot)

Report on, and evaluation of, the investigations

In case of samples close to the surface the quantity of suspended matter exerted a decisive influence on the transparency of water (VÉGVÁRI 1975).

The transparency values measured in the Tisza from June the 1st 1973 till December the 17th 1974 referred to an exponential connection in the function of the suspended matter (Fig. 2).

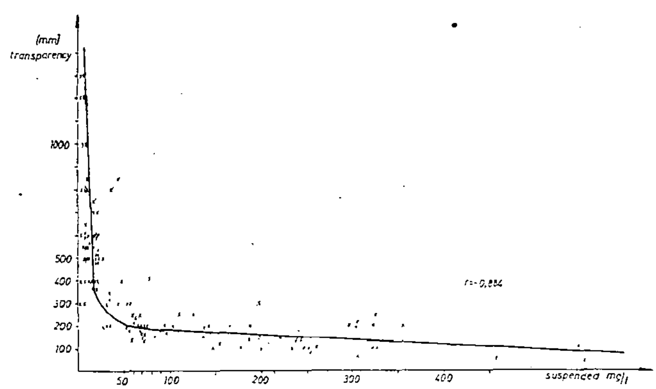

Fig. 2. Hypothetical connection between transparency and the total suspended matter in the current-line samples of the Tisza, from July 1973 till December 1974

The equation is of the type: $y=a.x$ whose constants were reckoned, after being linearized, with the least square method. Taking into consideration 91 cases, the equation is:

$$y = 2090 . x^{0\ 51}$$

— the closeness of the stochastic connection for the linearized form is: $r = -0.884$

$$r = \frac{\sum dx \cdot dy}{n \cdot \delta x \cdot \delta y}$$

The connection mentioned may be interesting because a connection of similar character can be demonstrated between the total algal number and suspended matter (ÁDÁMOSI *et al.* 1974). If the water is not toxic and its temperature is between (+)10—(+) 30 °C then, from the value of transparency, the other two characteristics, the order of magnitude of suspended matter and total algal number can be determined. We have referred that, of course, only to the Tisza reaches investigated by us, taking into consideration, as well, that in our case the factor inhibiting the multiplication of algae was mostly not the shortness of food.

In case of the natural and artificial lakes, the unfavourable (limiting) effect of a strong eutrophication on water utilization has urged all over the world more and more elaborated investigations, researches. The first period is characterized by the problem of "looking for a clue to the situation". And the new direction is marked recently by comprehensive function-connections. (RICH *et al.* 1972).

A considerable part is attributed to the effects of sediment, the load of the river, resp. suspended matter (HEMBREE *et al.* 1971), not only as to potential food depositories but also as to adsorbents, resp. absorbents of various matters that make a physico-chemical solubility system connected uniformly with the water masses above them.

The formation of the iron content of water and suspended matter may be interesting the theme (LEE 1971, GOLACHOWSKA 1971). According to our experiences, the total iron content was higher at flood and lower at small water. After comparing the maximum values to the change in the total suspended matter we could establish that a considerable part of iron content is bound to the suspended matter, increasing or decreasing in close connection with that (Fig. 3).

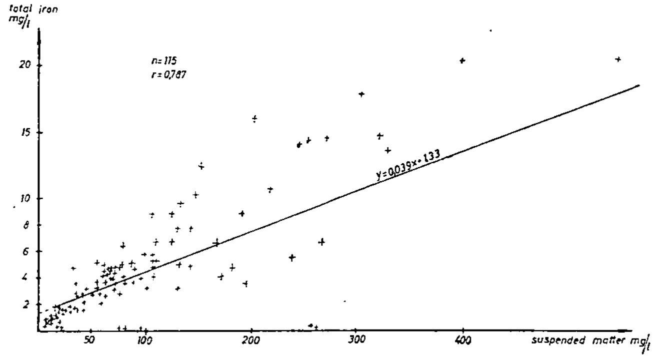

Fig. 3. Connection between the total iron and the total suspended matter content at the sampling points (1, 2, 3, 4) of the Tisza, in 1974

A further remark is that hardly 10 per cent of the total iron content is present in the water in dissolved form. The changes in concentration of the dissolved iron are determined physico-chemically. The change in the total iron content is an order of magnitude higher, even in absolute value.

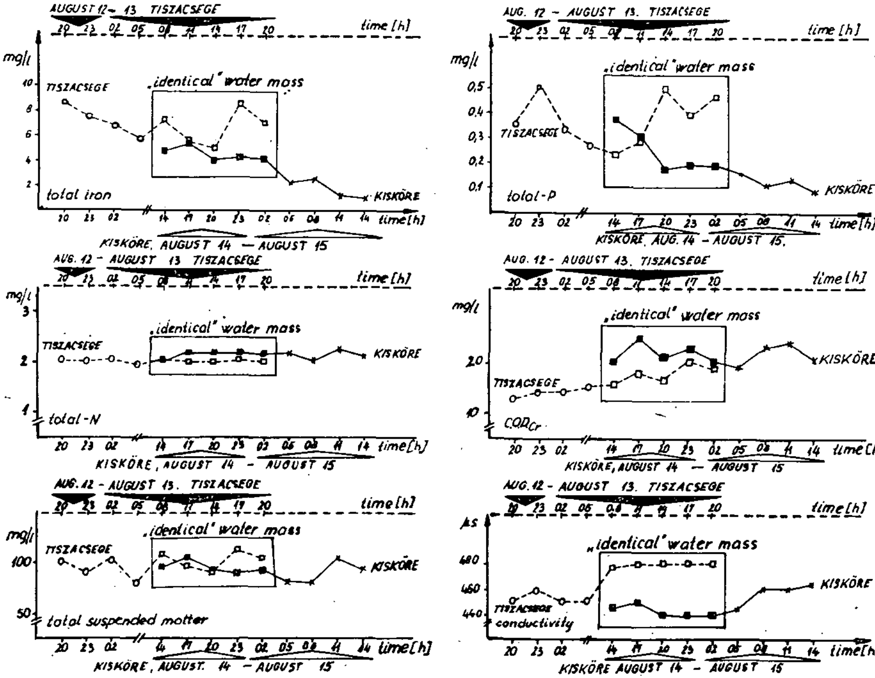

Fig. 4. Some components of the current-line samples of the Tisza at Tiszacsege and Kisköre

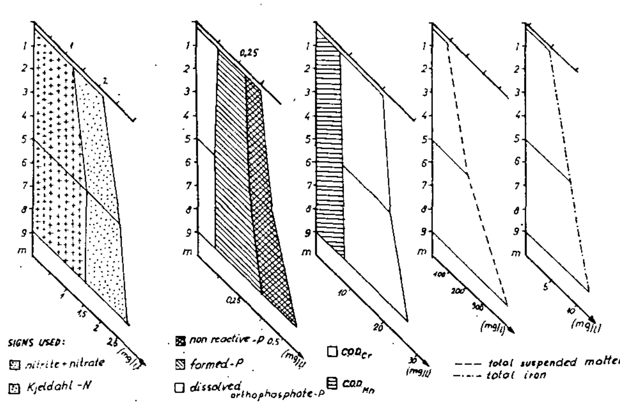

Fig. 5. Some components of the current-line vertical samples at Kisköre, at 14°°, August the 14th 1974

Are we supposing the connection between the total suspended matter and total iron content to be linear, then the equation, calculated with the same method as the former one was, is

$$y = 0.033x + 1.33$$

the value of "r" is 0.787; the number of points is 115.

In case of storage, most part of the iron coming with water settles together with the suspended matter and is accumulating in the sediment of the future reservoir. Here is to be mentioned the part of the sediment of high iron content as one of the factors of fish destruction induced by hydrogen sulphide (VÁMOS 1971), as well as the trophity-decreasing part of the well-settling complex and non-complex iron phosphates in the process of eutrophication.

The time passing between the single samplings was in the former cases one week, resp. a fortnight. River-water being in question, that time was far too much long, the intermediate changes cannot be taken into consideration. Shortening the time, and with regard to the water output, the number and site of samples, as well, we have reached the problem of optimizing.

On April 23rd and 24th 1974 we collected samples from the current-line of the river at Kisköre, in three-hour intervals.

The water output was 300 cc.m/sec. We sampled in the same place at 560 cc.m/sec water output on August 14th and 15th, as well as at Tiszacseg on August 12th and 13th, in a similar way. The starting date at Tiszacsege was determined on the basis of water speed measured at several points and in different depths, our purpose being to sample from an approximately identical water mass and to record the changes taking place in about 60 km reaches.

In order to form a more complete picture, we collected samples of depth at Kisköre on August 14th.

The results of the investigation are charted diagrammatically (Figs. 4, 5).

After elaborating these mathematically, we have drawn the following conclusions:

— in case of a lower water output (50—300 cc.m./sec), the relative dispersion of the surface samples of the current-line is larger than in case of 500—600 cc.m/sec water output. It appears from the results of vertical samples that the quantity of suspended matter is the largest in a depth of 5 to 9 m. The place of maxima was determined by the prevailing drif conditions (speed, specific surface, etc.).

— at measuring the suspended matter content and the components bound to that anyhow, the slightest error is made if we take samples from the depth indicated, possibly with the maximum suspended matter content, with friquency depending upon the water output. Sampling is to be carried out in case of a small water output more often, while in case of a large water output more rarely. In case of a small water output the samples characterize a smaller water mass, the system becomes unstable, the change is only followed by increasing the number of samples. In case of larger water outputs (500 to 3000 cc.m/sec) the system may be considered stable.

— Are we treating of bringing the sample number to the possibly highest perfection, then we have to show due regard, apart from the water masses, for the character of the water motion, as well. We must not ignore the influencing part of the river-bed structure, either. (Cf.: Fig. 1). The relative dispersion of the suspended mater content of vertical samples was namely 16 per cent at Tiszacseg, while at Kisköre it was 72 per cent, at identical water mass.

— the surface samples or those close to the surface are sufficient for determining the concentration of the materials found in dissolved state, because the river can be considered as homogeneous in regard of the dispersion of the dissolved components.

Our present results may give information for placing the automatic measuring stations planned, as well as for the recording frequency of the single components.

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DATA TO THE BACTERIOLOGICAL AND ALGOLOGICAL CONDITIONS OF THE REGION OF KISKÖRE RIVER BARRAGE

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(Received 30 June, 1975)

Abstract

The Kisköre River Barrage, built in the middle Tisza Region, began to damm up the water of the river in 1973. The present paper is making a survey of the bacteriological and algological results of the period passed since the damming. It is to be emphasized that, as a result of damming, a backwater plankton developed and the occurrence of the microorganisms indicating the eutrophic water became frequent.

Method

The investigation of the total bacterial count was carried out with the membrane filter method (Felföldy 1974). For elaborating the algological samples and counting Planctomyces bekefii, we have used Utermöhl's technique. At measuring the chlorophyll content, methanol solution was carried out (Felföldy 1974). From the beginning of damming we took longitudinal-section sampl's above the river barrage at four sites, below it at one site, in every month or fortnight. The bacteriological results were placed by István Bancsi at my disposal, the chlorophyll content was measured by MÁRIA B. TÓTH. Special thanks are due to them for that.

Results

Bacteriological investigations have so far been carried out in the Tisza only from hygienic point of view. The beginning of damming and the creation of the future reservoir lake made it imperative, however, to introduce hydrobacteriological investigations, as well. As a first step, it seemed to be advisable to determine the total bacterium count. At flood (Spring, early Summer, Autumn), the Tisza carries a considerable amount of organic suspended matter from the watershed area, with a rather high bacterium content (e. g., on June 18th 1974: 114 million ind./ml). On the basis of the recordings in 1974, the bacterium count generally changes as a function of the suspended matter carried by the floods. In 1974, this value fluctuated at the flood between 50—110 million ind./ml. In case of a small water output there is river-bed damming and then the total bacterium count is considerably lower (6—50 million ind./l). Some increase can only be observed in the time of a summer damming, taking into consideration that the backwater character, established in that way, is raising the trophic degree. In the longitudinal sector there cannot be demonstrated any significant deviations but the higher total bacterium count in the post-damming phase is striking. On the basis of our experiences, the bacterium count is not influenced essentially by the temperature.

It seems so that the total bacterium count will be suitable for separating from each other the water masses of identical water motion but of different pollution.

We have some data concerning the occurrence in the Tisza of *Planctomyces bekefii* GIM. (OLÁH et HAJDÚ 1973), belonging to the family Caulobacteriaceae (UHERKOVICH 1971). In the summer plankton of the dammed Tisza their quantity is considerable, maximum 5 million ind./l. It may be supposed that *Planctomyces bekefii* will be a good eutrophic indicator.

The algological conditions of the Tisza are rather well-known from Uherkovich's more than 15-year long activity. The summing up of the hydrobiological and algological results, achieved concerning the Tisza, is connected, as well, with his name (UHERKOVICH 1971). The effect of the dam, built above the Kisköre river barrage at Tiszalök, exerted upon the algological composition, could be demonstrated (UHERKOVICH 1960, 1961). After beginning the Kisköre damming (on April 16th 1973), the flowing speed of water decreased, the suspended matter settle down, making the water more transparent. Light can, therefore, penetrate deeper. The food solved in water became approachable. These changes have resulted in the qualitative and quantitative change of the algal stand in the river.

The most conspicuous was the transformation of the typical potamoplankton into limnoplankton (ÁDÁMOSI *et al.* 1974). Potamoplankton is characterized by the dominance of some alga species that tolerate the drifting, shearing effect of water [*Ceratoneis arcus* KÜTZ., *Diatoma vulgare* BORY, *Synedra ulna* (NITZSCH) EHR.], that is to say, first of all the diatom. It is characteristic of the qualitative composition

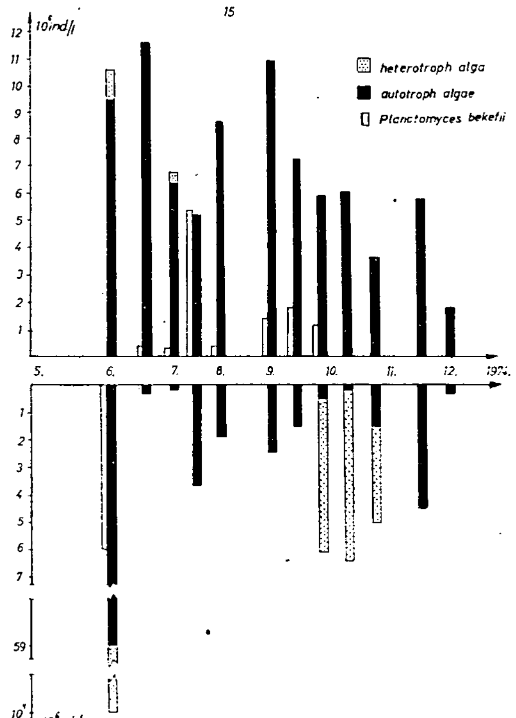

Fig. 1. Total alga count of the Tisza in the region of the Kisköre river barrage, on the basis of the investigations in 1974.

of limnoplankton that it consists partly of species found in potamoplankton in smaller individual number (*Nitzschia acicularis* W. SMITH, *Synedra acus* KÜTZ., *Fragillaria crotonensis* KITTON, *Asterionella formosa* HASSAL, *Nitzschia actinastroides* (LEMM.) GOOR, *Melosira granulata* var. *angustissima* MÜLL.), partly of backwater species occurring but rarely in potamoplankton or being so far unknown in the Tisza (*Stephanodiscus tenuis* HUST., *Cryptomonas marssonii* SKUJA, *Craytomonas ovata* EHR., *Cryptomonas platyuris* SKUJA, *Cryptomonas pusilla* BOCH., *Chrysococcus biporus* SKUJA, and cosmopolitan green algae — first of all the species *Ankistrodesmus*). The characteristic of limnoplankton is that *Staphanodiscus tenuis* HUST. is its dominant species, in association mostly with *Nitzschia acicularis* W. SMITH, *Asterionella formosa* HASSAL, *Melosira granulata* var. *angustissima* MÜLL., and *Fragillaria crotonensis* KITTON. In the summer plankton, besides the diatom, also the dominance of the species Chlorophyceae and Pyrrhophyta is considerable.

One month after the beginning of damming (May 17th 1973) the count: several millions ind./l of *Stephanodiscus tenuis* HUST. and *Nitzschia acicularis* W. SMITH was already indicating the change. On the basis of our experiences, the high individual count of *Stephanodiscus tenuis* HUST. always refers to a eutrophic environment. Something similar was observed in case of Lake Ontario (NALEWAJKO 1966) and other waters, as well (FOGED 1954). The total algal count may achieve several millions per litre, too, at the summer damming (Fig. 1).

The multiplication of algae is assured by the food content of the Tisza. It is, therefore, a result of the joint effect of suspended matter and temperature that the total alga count of a period can be separated well as a function of the suspended matter (Fig. 2), their correlation being significant.

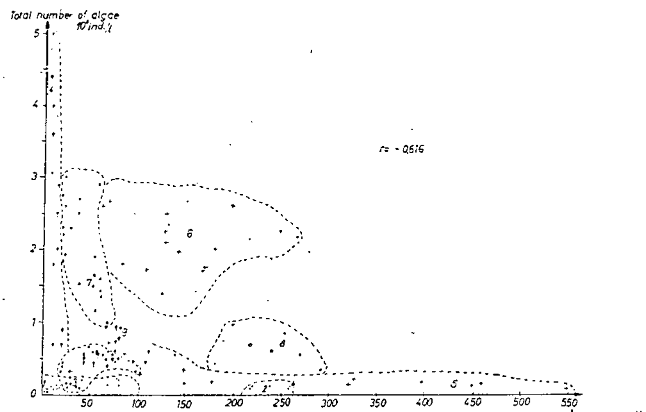

Fig. 2. Connection between suspended matter and total alga count.

If there is no damming, then the algological composition of the reaches investigated hardly changes, while at damming the alga count increases if we came nearer to the river barrage but after that it decreases (Fig. 3).

It is shown by the results of the chlorophyll content obtained in 1974 that at time of floods the chlorophlyl content is very low, while the values measured at damming are somewhat higher. The total chlorophyll content was fluctuating between 0.83 and 27.62 mg/cc.m. The maxima of the chlorophyll content were coinciding with the maxima of the total alga count, but owing to the low chlorophlyl values and methodical problems the correlation between them was not too strong, $r=0.503$.

The masses of benthic filamentous algae (*Cladophora, Spyrogyra* spp.), appearing after damming, are referring to the conditions changed, as well. The formation of

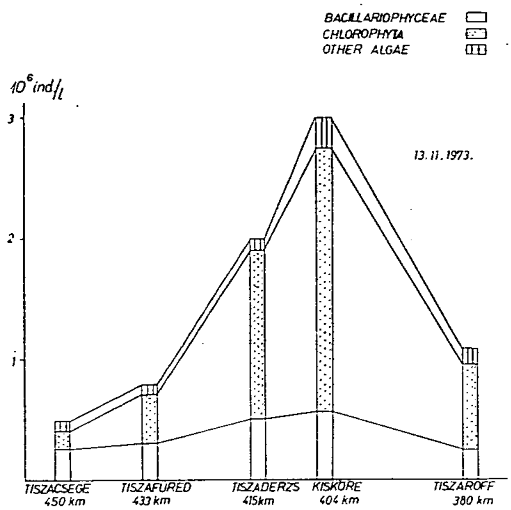

Fig. 3. Effect of damming on the algological composition of the Tisza in the Kisköre River Barrage region (November 13th 1973).

an eutrophic state is indicated by the algal blooms, too, before the river barrage. Although the blue alga, *Aphanizomenon flos-aquae* RALFS, that induces the frequent algal blooms, was not rare in the plankton, the algal blooms were here caused by *Microcystis aëruginosa* KÜTZ. and *Chlamydomonas reinhardii* DANG.

A large part of the limnoplanktic species may have originated from the polluted and eutrophic river, the Sajó, above the river barrage, and from the dammed reaches above the Tiszalök River Barrage, as well. In the Kisköre dammed reach a limnioplanktical algal stand of high species and individual count develops as a result of damming. We may suppose the development of a similar eutrophic stand in the future reservoirs, as well.

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Tiscia (Szeged) Vol. XI, pp. 45—58 (1976)

ABOUT THE ALGAE OF THE KISKÖRE RIVER BARRAGE AND ENVIRONS

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Abstract

The paper is characterizing the alga stand of the River Tisza and the change in it as a result of damming up the water. It is giving the description and depiction of some species that were unknown in the Tisza or are algological rarities.

Introduction

In order to satisfy the water demand of the people's economy — mainly of irrigation — reservoirs and river barrages have been established in the Tisza. The Kisköre Reservoir and river barrage established in the Middle Tisza Region is already functioning, and in the first phase the river bed is dammed up. In this way, only some rather flat areas got under water in the area of the future reservoir. Both large irrigation cannals are operating. It is worth while to remove the vegetation — containing woods, as well — from the reservoir area. For proving that, and for determining the economical way of removal, we have established an experimental area consisting of open-water parts and those covered with woods. Thus we could observe several interesting algae in the multivarious biotopes of the river barrage and environs.

Algological conditions of the River Tisza

The water motion of the Tisza is changeable, its water output is very variable (50 to 4700 cc.m/sec). Its current waves that result from rain and melted snow coming from its 157.000 sq.km watershed area have a high suspended matter content (on the average 500 to 600 mg/l). These conditions are determining the planktonic living world decisively. The fresh-water stand (eupotamoplankton), where the diatomaceous forms are predominating, is characteristic of the algological composition (UHERKOVICH 1958, 1959, 1965). In case of a small watter output and low suspended matter content in Summer, the mass multiplication of the stand is to be observed (UHERKOVICH 1968, 1969). As a result of damming up, the speed of the river is reduced, the suspended matter content settles down (5—10 mg/l), and in the water becoming transparent the river-water algal stand is replaced by a backwater stand (ÁDÁMOSI *et al.* 1974). Of the backwater plankton stand the high taxon-number and individual-number (max. 11 million ind./l) are characteristic. The species *Stephanodiscus tenuis* HUST., *Asterionella formosa* HASS., *Melosira granulata* var. *angustissima* MÜLL., *Fragillaria crotonensis* KITTON are dominant. The *Microcystis aeruginosa* KÜTZ., inducing algal bloom (efflorescence), and *Aphanizomenon flos-aquae* (L.) Ralfs are of not rare occurrence, either.

Description of some rather interesting species

1. *Dactylococcopsis raphidioides* HANSGIRG f. *mucicola* FRÉMY (Fig. 10)

The solitary cells are of faint bluish-green colour, spindle-shaped, their ends tapering off and being a little curved. The plasm is strongly granulated. No mucilaginous sheath covering is found. The size of the cell is 107×5.5 μ. It occurred on a single occasion in a navvy-pit in Summer.

2. *Oscillatoria acutissima* KUFF. (Figs. 2—4)

The thin, long trichomes stand alone. The cylindrical cells are 2.5 to 3 μ broad and 5 to 9 μ long. The apical cell is tapering, longer than the other cells, straight or curved. The transverse walls are slightly constricted. The bluish-green plasm is slightly granulated. Sometimes even larger granules may be found at the end of cells (Fig. 2). It occurs in the dammed up water of the Tisza in the summer months. Together with other algae (*Oscillatoria granulata* GARDN.) it forms coating on the trees, inundated by damming, in the vicinity of the river barrage, in the summer months.

3. *Oscillatoria terebriformis* AGH. (Fig. 5)

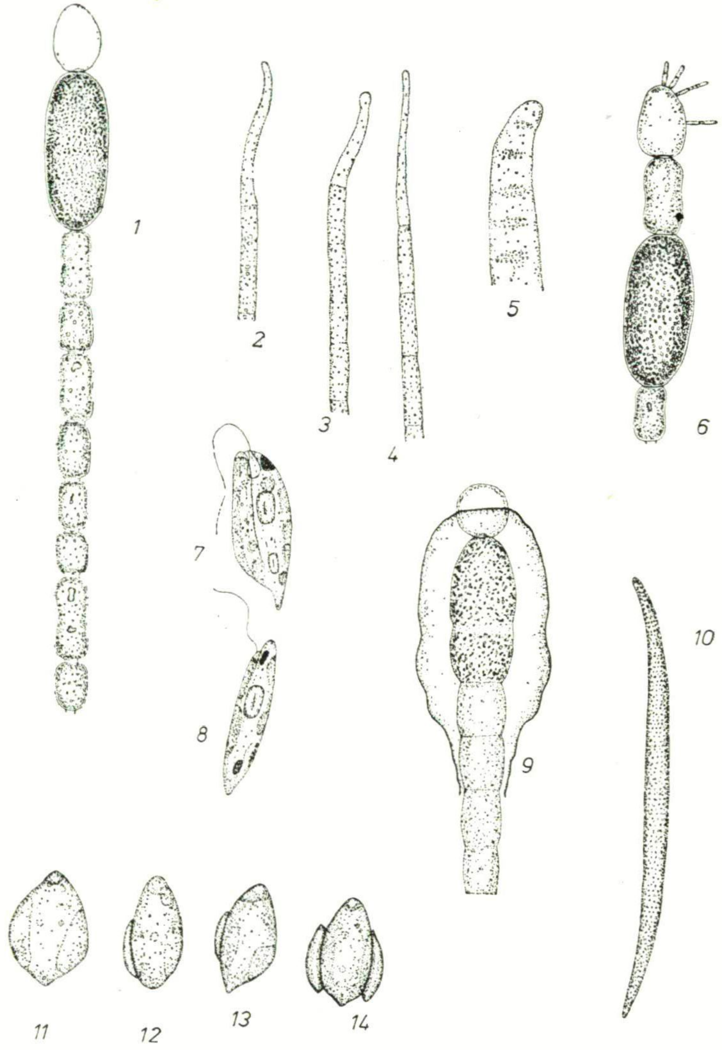
The trichome is of blush-green colour, slightly curved. The cells are mostly square, the transverse walls are slightly constricted in case of the older cells. The plasm is granulated at the transverse walls. The apical cell is rounded off or leveled out unilaterally. The size of cells is 6.5 to 7.5 μ. It makes coating in the watering zone of river-side stones of the dammed up Tisza, in Summer.

4. *Cylindrospermum stagnale* (KG.) BORN. et FLAH. (Figs. 1, 6)

The algal colony is flating free, it is of bluish-green colour. The heterocyst is transparent, oval, its size is 6 to 8 μ. The spore is cylindrical, rounded off at its ends, its interior is granulated. The cells are cylindrical, their size being 10 to 5, 5×4 to 4.5 μ. In the plasm smaller or larger granules are to be found. The cells are strongly constricted at the transverse walls. At teratological forms, the heterocyst is followed by one cell and then by the spore. It occurred in the summer months, in an area becoming marshy as a result of damming up.

5. *Gloeotrichia natans* (HEDWIG) RABENH. (Fig. 9)

The colonies as big as a fist are of olive-green colour, they are floating on the water surface. The heterocyst is roundish, 11 to 13 μ in diameter. The spores are cylindrical, at their end narrowed, their size being 35 to 70×10 to 15 μ. The cask-shaped and cylindrical cells are slightly granular, in the periphery of spore they are 12 to 15 μ thick. The trichome is gradually tapering. It is surrounded by an undulant capsule starting from the heterocyst of spore. As going towards the cells, this is tapering and then ceases to be. It occurred in the Autumn, along the marshy riverside of the area filled up with Tisza-water.



6. *Phacus skujae* Skv. (Figs. 7—8)

The cell is thin spindle-shaped or bulged. In its front part it is rounded, in the back part, after tapering, it ends in a blunt apex or blunt point. The pellicula is a little metabolic, finely costate. The flagellum is cell-long or shorter. One or two of the paramylons are ring-shaped. In the lumen, smaller or larger chloroplasts are to be found sporadically. The stigma is well-visible. The size of cells is 20 to 25×5 to 9 μ. In the Autumn, it occurred in the open water of the experimental area filled up with Tisza-water.

7. *Lepocinclis fusiformis* (CARTER) LEMM. var. *podolica* (DREZ.) POPOVA (Figs. 11—14)

The solitary cells are spindle-shaped. In their front part they are rounded, their back part ends in a blunt apex. Their two big paramylons take place on the side, sitting close to the cell-wall. In several cases, the paramylons protrude from the cell. One or two big granules may mostly be found at the cell apex. The chloroplast is tiny, circular, and there were very few of them in the cells investigated. There occurred no stigma. The size of cells is 24 to 27×14 to 17 μ. It occurred in the irrigation canal coming from the sector dammed up.

8. *Chroomonas acuta* UTERMÖHL (Figs. 15—17)

It is a spindle-shaped cell. In its front part it is rounded broadly, sometimes with a recess; in the back part it is curved and ends after tapering in a blunt or sharp point. The lumen is not filled in with plasm in every case. A large olive-coloured chloroplast is adhering close to the cell-wall. Apart from the small granules found scattered in the plasm, a rather big pyrenoid takes place in the front part of the cell. The two flagella are of cell-length or shorter than that. The size of cell is 7 to 10×4 to 5 μ. They often occur in large numbers in the water of the dammed Tisza and in the areas inundated by damming.

9. *Cryptomonas pusilla* BACH. (Figs. 18—19)

The egg-shaped cell is rounded and cut one-sidedly in front, in its back part, after tapering, it ends in a blunt apex. One large parietal chloroplast is to be found. In addition to more tiny granules there occurs a larger pyrenoid, as well. The large leukosin body in the back part is very characteristic. The cell is metabolic, its size is 10 to 13×6 to 8 μ. It is a frequent organism of the river reaches dammed up and of the areas inundated by damming. Sometimes it occurs in large numbers.

10. *Cryptomonas platyuris* SKUJA (Fig. 21)

They are oval, large cells, rounded in front and ending in a short rostrum, at the back they are a little curved and rounded. Two large brownish-green chloroplasts are sitting close to the colourless periplast. In the plasm several starch granules of smaller or larger size take place. The contractile vacuole is to be found under the rostrum. Two flagella originate beside the rostrum, the shorter ones at the cell. The size of the cell is 40 to 52×19 to 23 μ. In the dammed Tisza and environs it is a very frequent organization.

11. *Cryptomonas rufescens* SKUJA (Fig. 22)

It is an oval cell, rounded in front and ending in a small blunt rostrum. Tapering at the back, it is rounded broadly. Two olive-cholored large chloroplasts are sitting close to the periplast. The nucleus is to be found in the back part of the cell. Pyrenoid is missing, several small starch granules are to be found sporadically in the plasm. In the front part of the cell there is one contractile vacuole. The size of the cell is 20 to 25×9 to 11 μ. It is frequent in the dammed Tisza and environs.

12. *Chilomonas acuta* SCHILLER (Fig. 25)

It is a spindle-shaped cell, in front rounded broadly, at the back, after tapering, it ends in a curved apex. Its two flagella are shorter than the cell itself. In the plasm one to three rather big starch granules and several small granules take place. The size of the cell is 22 to 28×9 to 10 μ. It occurred in an area inundated with dammed water. It is rare.

13. *Glenodinium* sp. (oculatum STEIN?) (Figs. 23, 26)

The cell is oval or spheroid, the valvae are of similar size and semicircular. The nucleus is central, in the plasm there are tiny chloroplasts. The cell is 20 to 23 μ long and a little shorter. The structure of valva is somewhat changing. It occurred in the marshy water inundated by damming. It is rare.

14. *Peridiniopsis quadridens* (STEIN) Bourrelly (Fig. 24)

The epivalva of the oval cell is cone-shaped, the hypovalva is rounded broadly. On both sides of the hypovalva two smaller spines and in its low part two bigger ones are to be found. The size of the cell is 34 to 35×30 to 32 μ. It is a frequent organization in the summer plankton of the experimental area inundated with Tisza water.

15. *Peridinium bipes* STEIN (Fig. 20)

It is a more of less oval cell of 65 to 63 μ size. In the low part of the hypovalva two strong spines are to be found. It occurs sporadically in the plankton of the experimental area inundated with Tisza water.

16. *Ochromonas pallida* KORSCH. (Fig. 29)

The cell is heart-shaped, very metabolic. It has one chromatophore taking place in its front part. One vacuole can be found in the middle of the cell. The plasm is granular, having a longer and a shorter flagellum. The size of the cell is 6×4 μ. It is to be found in the eutrophic water of the dead channel inundated with Tisza water, at algal bloom. It is rare.

17. *Chrysococcus biporus* SKUJA (Fig. 27)

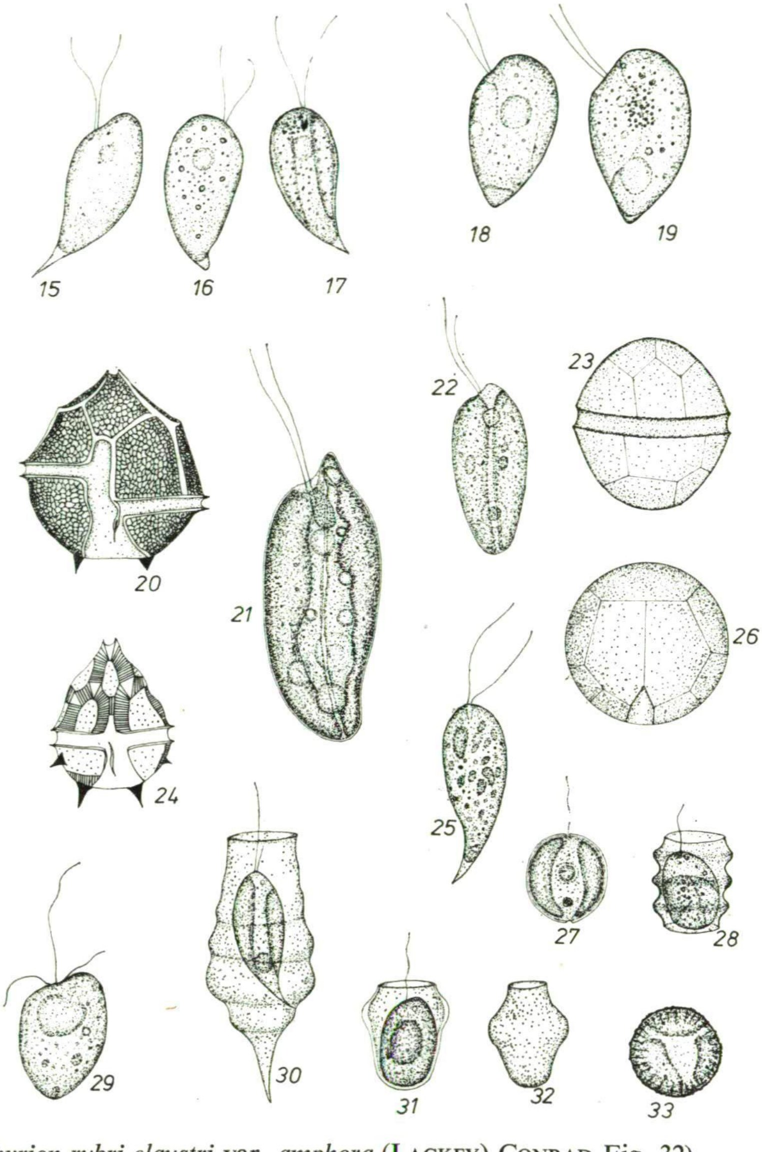
The lorica a spherical, of greenish of red-brown colour. At both poles a pore can be found each whose position is not always symmetrical. The size of the lorica is 6.5 to 9 μ, it is but rarely granular. The lumen is filled in by the plasm. It has two parietal chromatophores. The nucleus is central. Sometimes one contractile vacuole can be observed under the flagellum protruding through the anterior pore. It is very frequent in the water of the dammed up Tisza and in the areas inundated by damming.

18. *Kephyrion tubiforme* FOTT (syn. *Stenocalyx tubiforme)* (Fig. 28)

The lorica is cylindrical, its wall is a little thick. At the margin of the lorica three-four spirals are running down. The spiral is mostly deep and rounded. The size of the shell is 9 to 10×5 to 6 μ. The cell lying in the shell is oval, it contains one chromatophore and one flagellum. It occurred in the water of the irrigating canal filled up by damming, in the winter months. It is rare.

19. *Kephyrion rubri-claustri* Conrad (Fig. 31)

The oval lorica is cut above, in the front part there is a broadening ring, below it is rounded broadly. The size of the lorica is 6 to 7×5 to 6 μ. The cell is oval, it has a chromatophore and a flagellum. It occurred in the summer plankton of the irrigation canal filled up by damming. It is a frequent species.



20. *Kephyrion rubri-claustri* var. *amphora* (Lackey) Conrad Fig. 32)

The lorica is strongly bulging in the middle, in the front part it is narrowing, in the back part it is rounded broadly. The size of the lorica is 10×7.5 μ. It occurred on a single occasion in the water of the experimental area.

21. *Monas cylindrica* SKUJA (Figs. 34—37)

The cell is cylindrical, strongly metabolic, rarely amoeboid. Beside the peristom lying in the front part there are originating two flagella of different length. The longer one is about double the cell, the shorter one is half a cell in length. The plasm is strongly granular, with several food vacuoles. The nucleus is central, one contractile vacuole takes place in the front part. The size of the cell is 10 to 15×3 to 6 μ. It is frequent in the marshy water of the area inundated by damming.

22. *Monas uniguttata* SKUJA (Figs. 38, 44—45, 51)

The solitary cell is oval, above a lip-shaped process can be seen, below it is rounded and fixed to the lower part with a thin thread. The periplast is thin and metabolic. The plasm is granular, the nucleus is central. The contractile vacuole can be found in various parts of the plasm. Beside the peristom we can notice two flagella of unequal length. The longer one is the treble of cell-length, the shorter one does not reach the size of the cell. The size of the cell is 6 to 7×4.5 to 6 μ. The stem is 7 to 15 μ long. It is living in the water of the marshy area inundated by damming.

23. *Oicomonas termo* (EHR.) KENT (Figs. 39—43)

The cell is oval, very metabolic. The rostrum lying beside the origination of the flagellum, the front part is characteristic of it. The plasm is strongly granular, containing several food vacuoles. The nucleus is central. Sometimes a contractile vacuole is to be found, too, in the front part. It may occasionally be very large. It feeds, first of all on algae, by opening the peristom quickly. The flagellum is of double cell length. The size of the cell is 12 to 17 μ. It often occurs in the water of the marsh established by damming.

24. *Chrysochromulina parva* LACKEY (Fig. 46)

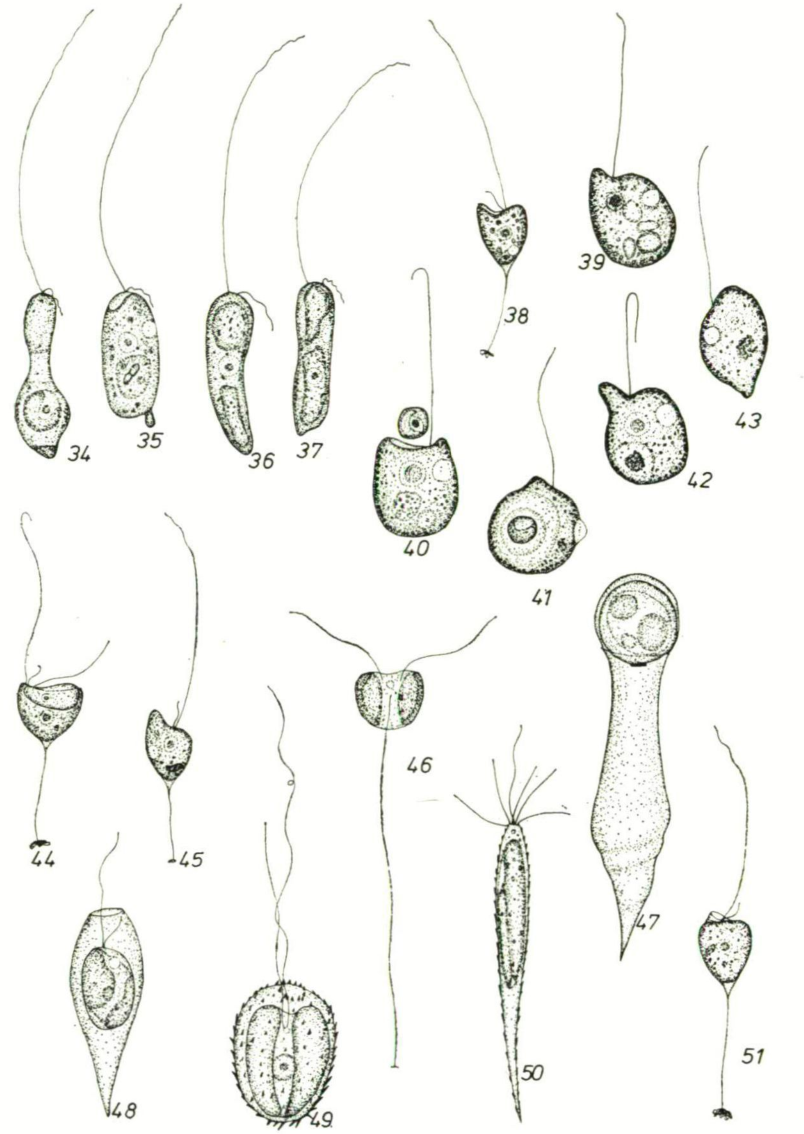
The cell is spherical in front-view, a little metabolic. In the front part with a small recess, in the back part it is rounded broadly. It has two parietal periplasts, the plasm is finely granular, the contractile vacuole is to be found in the front part. In front, two equal flagella of double cell length obtrude. The cell is 5 to 7 μ in diameter. From the middle of the cell a thin, long fibril reaches back and fixes the cell. It can often reach even the twentyfold length of the cell. It was found in the plankton of the experimental area in Summer.

25. *Dinobryon elegantissimum* (KORSCH.) BOURR. (Fig. 30)

The spindle-shaped shell is cut off above, in the middle it is broadening and wavy, below it is ending constricted in a thin point, its size being 30 to 35×9 to 10 μ. The cell lying in the shell is thin spindle—shaped, above rounded, below it adheres to the wall of shell, tapering away. It has two chromatophores, the contractile vacuole is to be found in the front part. Its flagella of different length do not surpass the length of the cell. The size of the cells is 16 to 18×6 to 7 μ. The species is solitary, floating free. If often occurs in the areas becoming backwaters by being dammed up.

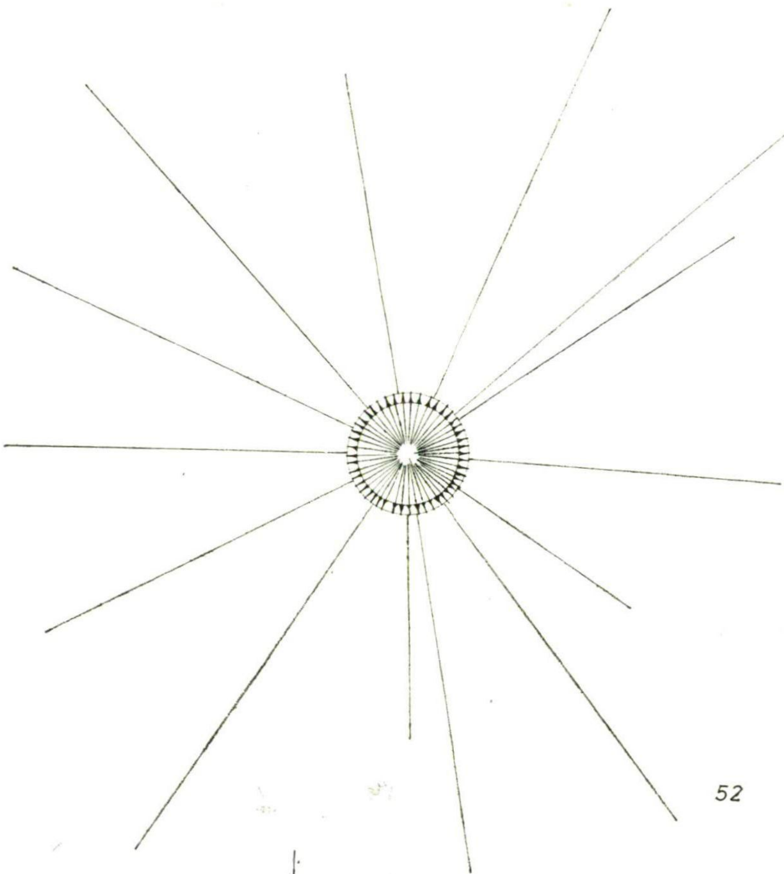
26. *Dinobryon marchicum* Lemm. (Fig. 48)

The thick thalli is spindle-shaped, above cut off, below it adheres to the lower part, tapering away. Its size is 20×9 μ. The cell is oval, it contains one chromatophore and one contractile vacuole. It has two flagella of different length. It occurred in the plankton of the experimental area, fixed to a floating bottom. It is rare.



27. *Dinobryon divergens* IMHOF (Fig. 47)

In the water of the drying dead arm this species induced algal bloom and after that the destruction of the alga mass began. There could be observed a cyst formation at about 5 per cent of the individuals found. The 10 to 13 μ thick cyst was drawn out of the thalli, drawing after itself a membrane that was thinner than the thalli. The membrane, after leaving the shell definitely, took on the shape of the cyst, forming a capsula for protecting the cyst.



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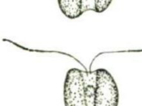

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28. *Mallomonas akrokomos* RUTTNER? (Fig. 50)

The shell is elongated spindle-shaped, narrowed in the lower part. The spines are thin and curved, protruding from the front end of the shell. The plasm fills in the lumen, two chromatophores and several vacuoles are to be found in it. The flagellum is half-a-cell long. The size of the cell is 25 to 45×4 to 8 μ. It occurred in the summer plankton of the experimental area.

29. *Malomopsis pelophila* (LUND) FOTT (Fig. 49)

The cell is oval, a little metabolic. Round the aperture found in the front part some tiny spines take place. Two chromatophores are parietal, the nucleus is central. It has two flagella of different length. The size of the cell is 17×2 μ. It occurred in the water of the Tisza dammed up. It is of rare occurrence.

30. *Dinobryon suecicum* LEMM. (Fig. 54)

The cylindrical thalli is of asymmetrical construction, above cut off, below narrowing. A thin, spiral ring is running down the thalli. The size of the thalli is 20 to 22×4 to 5 μ. The cell is elongated oval-sized, with two chromatophores. The species is always solitary. It often occurs in the plankton of the experimental area.

31. *Chrysidalis peritaphrena.* SCHILLER (Figs. 57—58)

The solitary cell is in front-view oval or a little cornered. In side-view it is flat, a litle curved. It has two parietal chromatophores, the nucleus is central. Its both flagella of equal length are about double the cell-size. The size of the cells is 10 to 14 μ. It is of frequent occurrence in the plankton of the experimental area.

32. *Hetrolagynion oedogonii* PASCHER (Fig. 55)

The lorica has thick walls, it is below rounded broadly, above cut off. From the plasm a thin, long, pointed rhizopodium protrudes. The size of the cell is 6×7.5 μ. It occurred on a single occasion in the water of the experimental area, on a Tribonema thread.

33. *Stephanodiscus tenuis* HUSTEDT (Figs. 33, 52)

The cells are 7 to 15 μ in diameter. The thin, radial costae are ending at the borders in tiny spines, of which 20 to 22 may be found in 10 μ. It has frequently several spines for making it float. The length of these may be manifold of the cell diameter, as well (Fig. 52). It occurs that the shell of the spineless forms becomes thick (Fig. 33). It often occurs in the areas inundated by being dammed up, and in the water of the dammed Tisza it can sometimes be found in large numbers.

34. *Cymbella affinis* KÜTZING (Fig. 56)

The size of the cells is 22 to 24×9 to 10 μ. In 10 μ 12 to 14 transapical stripes can be found. It is interesting that the central part of the ventral side doesn't widen out in every case but it is often constricted in various degree. It is forming grass in the irrigating area of the river barrage.

35. *Navicula dicephala* (EHR.) W. SM. var *undulata* ÖSTRUP. (Fig. 53)

The size of the cell is 18.5×8 μ. In 10 μ 12 to 13 transapical stripes can be found. The size of the cell is smaller than that given in the literary data. (CLEVE—AULER, 1951—1955). It occurred on a single occasion in the water of the dammed up Tisza, in Summer.

36. *Synura globosa* (SCHILLER) STARMACH (Fig. 64)

The cells live in colonies. They are spherical, on their surface the spines of lamellae are well-visible. They have two big parietal chromatophores and two contractile vacuoles can be seen under the origination of flagella. The two flagella of equal length are one and a half times as long as the cell size. The cells are 11 to 12 μ in diameter. It occurred in the summer plankton of the dammed up Tisza.

37. *Chlamydomonas reinhardii* DANGEARD (Fig. 59)

The elliptical cell is above a little constricted, below broadly rounded. The membrane is thick, without papilla, it often secretes a thick gelatinous matter that bacteria may adhere to. The chromatophore is uniform, a little granular. The nucleus can be found in the front part, below it a large spherical pyrenoid takes place. The conctractile vacuole is seen in the front part, the flagella one and half times as long as the cell are of equal size. The stigma is tiny or not suitable for being observed. The lumen is not in every case filled in with plasm. The size of the cells is 13 to 16 μ. It is of frequent occurrence in the water of the dammed up Tisza.

38. *Carteria cordiformis* (CARTER) DILL (Figs. 64, 67—68)

The form of the cell is multifarious, being spherical or heart-shaped, in front deepened, below rounded. The chromatophore is big, the pyrenoid elliptical. Below the origination of the four flagella — about as long as the length of the cell — one or two contractile vacuoles take place. There is no stigma to be seen. The size of the cell is 13 to 16 μ, smaller than those of the literary data (PASCHER 1927). It often occurs in the spring plankton of the experimental area.

39. *Carteria cordiformis* (CARTER) DILL forma? (Figs. 60—62)

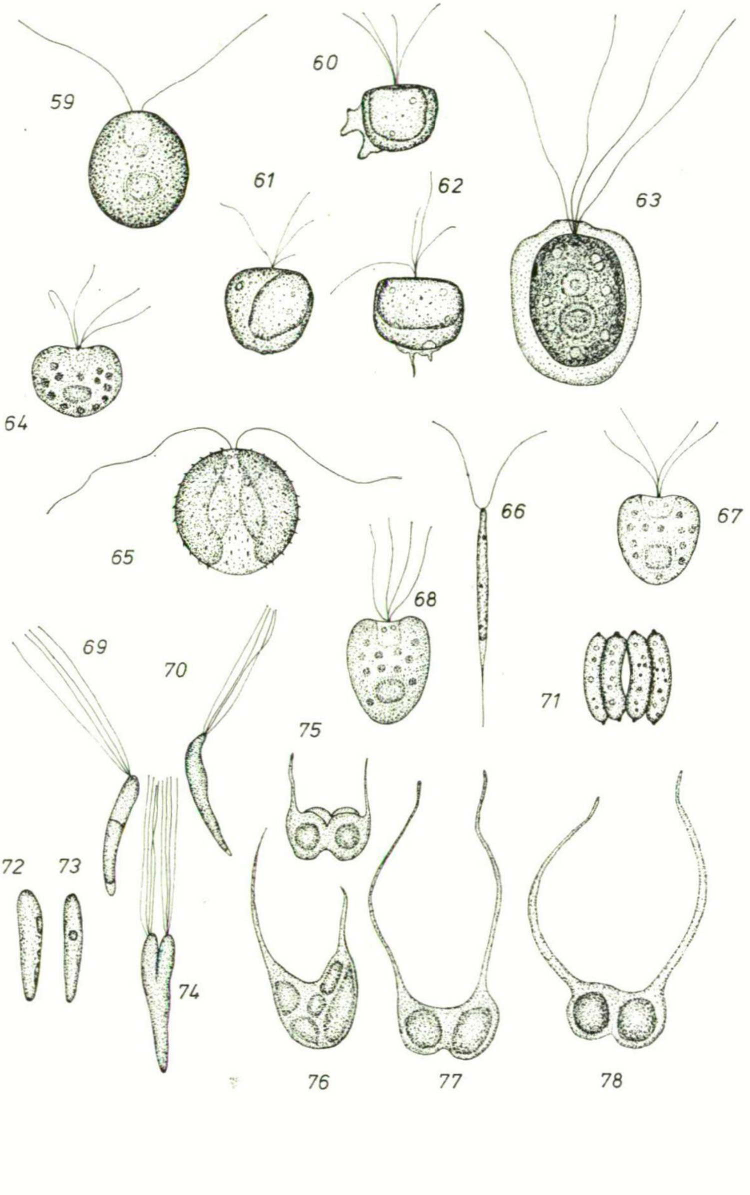
The cells are very tiny, their size being 4.5 to 5.5 μ. The membrane is thin, metabolic, sometimes amoeboid. In the plasm a big pyrenoid and tiny chromatophores are to be seen. It was found on one occasion, in the summer plankton of the dammed up Tisza.

40. *Carteria peterhofiensis* KISS. (Fig. 63)

The cell is elliptical, in the front part a large papilla takes place. The lumen is not filled in entirely by the plasm. It has a big chromatophore. The nucleus is to be found in the front part, just under it with the elliptical pyrenoid. The stigma is to be seen in the anterior part. The four uniform flagella are a little longer than the cell. The size of the cells is 28 to 30×20 to 22.5 μ. It was found in the summer plankton of the experimental area.

41. *Chlorogonium minimum* PLAYFAIR (Fig. 66)

The cell is elongated spindle-shaped, in front ending in a tiny head, while at the back it is tapering and ending in a long point. The two uniform flagella are about as long as half a cell. The lumen is not filled in completely by the plasm. The chromatophore is big, without any pyrenoid. The stigma and nucleus were not to be seen. The size of the cell is 20×1.5 μ. It occurred on a single occasion, in the summer plankton of the experimental area.



42. *Spermatozopsis exultans* KORSCHIKOV (Figs. 69—70, 74).

The slightly curved cell is spindle-shaped, in the front part it is rounded, in the back part sharp-pointed. The plastis is large, the lumen is nearly completely filled in with it. The size of the cell is 8 to 9 μ. The four uniform flagella oft double the cell-length. The cell division is horizontal. It occurs in the plankton of the experimental area sometimes in masses.

43. *Scenedesmus raciborskii* WOLOSZ f. *granulatus* HORTOB. (Fig. 71)

Its four-cell coenobium cells are cylindrical, arched. In the poles, a papilla can be found each. The size of the cells is 12×2.5 μ. It was found on a single occasion in the summer plankton of the experimental area.

44. *Elakatothrix gracilis* HORTOB. (Figs. 72—73)

One cylindrical half of the cell is straight while the other is slightly curved. The poles are rounded. The chonmatophore is simple, it fills in the lumen. It has a pyrenoid The size of the cells is 5 to 10×1.5 to 2 μ. The cells are always solitary, the cell appears in the water of the flooding river, the spines therefore break and come off.

45. *Chaetopedia crassiseta* SKUJA (Figs. 75—78)

The spherical cells form a coenobium in twos and fours. Its size is 7.3 to 10 μ. From the cells, spines of different length protrude, ending in a curved, thin point. It occurred on a single occasion in the summer plankton of the dammed up Tisza.

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ZOOPLANKTON INVESTIGATIONS IN AN EXPERIMENTAL AREA AT THE KISKÖRE RIVER BARRAGE

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Abstract

In the course of our investigations the differences between the areas of various physiognomies concerning their composition of species and individual numbers indicated the consequences of the different organic-matter loading of the open-water and woody-bushy water surfaces and, in that way, the early ageing of the latter one, the deterioration of the water quality in it.

Introduction

After creating shallow-water reservoirs, the plant remains of the inundated areas provide a continuous food supply to the aquatic animals with their decomposition lasting for several years. The outcome of that may be a rise in the saprobity degree of water and necessarily a quicker tempo of the process of eutrophication. In 1974, therefore, our laboratory carried out hydroecological investigations in an experimental area of an about 4 sq.km surface, of 1 to 3.5 m water-depth, overgrown with trees and shrubs, inundated with the water of the Tisza that will give food-water also to the Kisköre Reservoir to be created in the Tisza, for establishing parallelisms and differences between the water qualities of the areas of different vegetations, overgrown with woods and having open-water sites. In the course of the work we performed hydrochemical (H. TÓTH 1975), bacteriological and algological (HAMAR 1975) investigations and studied the macrovegetation (B. TÓTH—HAMAR 1975). On many occassions, the diurnal changes were followed with attention, as well (HAMAR—BANCSI 1975).

Material and method

In the course of investigating the experimental area, we have studied the qualitative and quantitative development of the zooplankton (Zooflagellata-, Rotatoria- and Crustacea-fauna) systematically. The elaboration of the Zooflagellata fauna was performed by my colleague J. Hamar. I am most grateful to him for abandoning me his results. From the five sampling points designated (B. TÓTH—VÉGVÁRI 1975) we ladled samples weekly, resp. fortnightly. For collecting the species Rotatoria and Crustacea, we have used a net made of 50 μ mesh sieve cloth. Occasionally and at some point we have filtered 10 l water for the quantitative elaboration and 50 to 100 l water for qualitative investigations, the latter one being used for the determination of all the three groups from living samples. The quantitative investigation of the Zooflagellate fauna tok place from ladled samples, fixed with Lugol's solution, according to Utermöhl's technique.

Results

From the water of the experimental area we have identified 16 Zooflagellate species, namely: *Acinetactis mirabilis* KENT, *Bicoeca conica* LEMN., *B. lacustris* J. CLARK, *B. planctonica* KISS, *B. turrigera* BOURR., *Cercobodo dubius* SKUJA, *Codonosiga botrytis* (EHR.) KENT, *C. ornata* ROSKIN, *Collodyction tricilliatum* CARTER, *Desmarella moniliformis* KENT, *Diplosigopsis entzii* FRANCÉ, *Monosiga ovata* KENT, *Pleuromonas jaculans* PERTY, *Poteriodendron petiolatum* STEIN, *Salpingoeca bütschlii* LEMN., *S. frequentissima* (ZACH.) LEMN.

Among the species turning up we have not found any indicating expressly polluted water although *Acinetis mirabilis* was found in an oxidizing lake, *Collodyction tricilliatum* below the inflow of waste-water from the paper-mill of Szolnok into the Tisza (HAMAR 1973). The majority of species contain organisms living in eutrophic waters.

The Rotatoria fauna of the experimental area is rich both in species and in individual numbers. In the course of the investigations 95 taxons were found. In Table 1, from the data obtained during the annual investigation of the five sampling points, only the data of the samples coming from three characteristic periods of two sampling points (15 = open water, 15/3 = wooded area) are recorded.

In the Rotatoria plankton of the shallow backwaters, apart from the euplanktonic forms, there occur regularly phytophilous and pelophilous species, as well. The obligate planktonic species are characteristic members of the water living-spaces during the whole year. The multipliaction of the phytophilous species, containing constantly bottom-bound (sessile) forms and some groups becoming fixed only periodically (metaphytic species), is connected with the appearance and spreading of the macrovegetation.

After the experimental area had been filled up, we could evaluate the conditions developed in the water spaces of various physiognomies, on the basis of the results of the Rotatoria-plankton investigations, as well: In the open-water area initially the *Keratella-Polyarthra — Synchaeta*, then in July the *Keratella — Anuraeopsis — Brachionus — Polyarthra* plankton were characteristic. In August, the Rotatoria plankton of *Brachionus — Keratella — Filinia*, in September that of *Keratella — Polyarthra — Trichocerca*-composition developed. In the *Keratella — Polyarthra — Synchaeta* plankton, characteristic between October and December, only the dominance of the three genera underwent a change. In the wooded areas from May the 28th till July the 2nd we found Keratella, in the middle of July *Anuraeopsis — Keratella,* at the end of July *Anuraeopsis — Keratella — Polyarthra — Trichocerca* plankton. In August, *Keratella — Brachionus — Polyarthra,* then *Polyarthra — Pedalia — Pompholy* plankton developed. In September, we found *Keratella — Polyarthra* plankton. From October, similarly to the open-water areas, the *Keratella — Polyarthra — Synchaeta* plankton became characteristic here, too. At assorting the plankton types observed in the course of the year, the dominant genera were taken into consideration. On this basis a considerable similarity may be established. But *Fedalia mira* and *Pompholyx sulcata,* found in large numbers in the wooded area inundated with water and causing the dominant appearance of their genera, are referring to the difference of the two water-spaces of different physiognomies, as well.

In July, *Anuraeopsis* fissa was one of the dominant species of the open-water area. In the wooded places it appeared similarly in July and its number was here the multiple of that observed in the open water. Among the characteristic species of the open-water area also *Conochiloides dossuarius* is to be mentioned, although we know rather little about its ecological value.

The richness in form of the genus *Keratella* was striking: there occurred together eleven taxons in the experimental area. In the epxerimental period, there were found only 2 to 5 taxons of the genus in large numbers, now and again. The plankton could be characterized therefore by this group almost in the whole year. The distribution of the taxons found was not uniform. In the open-water parts, the numbers of *Keratella cochlearis* var. *marcacantha, K. cochlearis cochlearis, K. cochlearis* f. *microcantha, K. cochlearis* var. *tecta, K. cochlearis* var. *hispida* f. *pustulata,* and *K. quadrata* were considerable, in the parts grown with woods the genus was represented in large numbers by *K. testudo* and *K. testudo gossei.*

The phytofilous Rotatoria species, following the distribution of the aquatic macrovegetation, got into our plankton samples in species and individual numbers increasing progressively. The planktonic and metaphytic species found in the open-water area *(Anuraeopsis fissa, Brachionus falcatus, Br. quadridentatus, Colurella uncinata, Filinia longiseta, Flscularia ringens, Lecane bulla, L. luna, L. quadridentata, Siantherina socialis, Trichocerca bicristata, Trichotria pocillum)* have indicated a eutrophic backwater.

In the woody-shruby areas we have often found some species *(Euchlanis lyra, Lecane stenroosi, Lecane ungulata, Lepadella acuminata, L. rhomboides, Mytilina mucronata, Trichotria tetractis)* that are the dwellers of strongly overshaded, shallow backwaters, grown old and rich in humus-matters.

The result of the quantitative investigations is proving the lively population-dynamics of the Rotatoria plankton (Fig. 1).

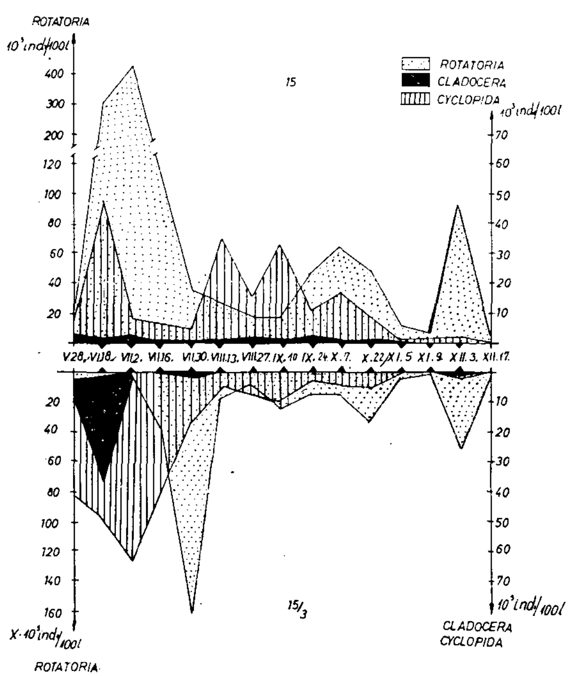

Fig. 1. The quantitative dynamism of the Rotatoria, Cladocera, and Cyclopida plankton in an open-water site (15) and in one covered with woods (15/3)

Taxon Sampling time Sampling points	June 18 15	June 18 15/3	August 27 15	August 27 15/3	October 7 15	October 7 15/3
ROTATORIA						
Anuraeopsis fissa (GOSSE)	2 700	0	0	1 100	0	600
Ascomorpha ecaudis PERTY	0	0	0	0	700	0
Asplanchna priodonta GOSSE	800	0	140	0	440	0
GOSSE *Brachionus angularis*	1 600	0	1 200	800	280	0
Br. calyciflorus var. *dorcas* (GOSSE)	0	0	400	0	0	0
Br. calyciflorus var. *dorcas* f. *spinosa* (WIERZ.)	0	0	380	0	0	0
Br. calyciflorus f. *amphiceros* (EHRB.)	0	0	0	0	30	0
Br. falcatus Zacharias	0	0	3 600	190	0	0
Br. quadridentatus var. *typica* HERMANN	0	0	290	90	90	0
Cephalodella gibban (EHRB.)	0	0	0	0	70	0
Conochiloides dossuarius (HUDSON)	0	0	150	0	0	0
Dicranophorus caudatus (EHRB.)	0	0	0	0	0	180
Euchlanis dilatata EHRB.	0	0	30	0	0	0
Filinia longiseta (EHRB.)	3 600	0	1 200	260	120	0
Keratella cochlearis cochlearis (GOSSE)	132 000	1 800	1 100	0	150 000	2 900
K. cochlearis var. *hispida* f. *pustulata* (LAUT.)	77 000	0	0	0	0	0
K. cochlearis var. *irregularis* f. *angulifera* LAUT.	0	0	0	300	2 900	3 000
K. cochlearis var. *irregularis* f. *angulifera* LAUT.	0	0	0	300	2 900	3 000
K. cochlearis f. *micracantha* LAUTERBORN	800	0	1 900	0	700	1 400
K. cochlearis var. *tecta* (GOSSE)	13 000	0	1 300	0	1 400	0
K. testudo (EHRB.)	0	0	0	0	50	4 400
K. valga (EHRB.)	0	0	950	0	0	0
K. quadrata (O. F. MÜLLER)	1900	0	0	0	0	0
Lecane bulla (GOSSE)	0	0	0	80	0	0
Lepadella rhomboides (GOSSE)	0	0	0	0	0	30
Lophocharis salpina (EHRB.)	0	0	0	100	30	0
Pedalia mira (HUDSON)	0	0	660	4 900	0	0
Platyias quadricornis var. *pentagona Wulfert*	0	0	0	20	0	0
Polyarthra euriptera WIERZEJSKI	0	0	700	0	0	0
P. major BURCKHARDT	7 500	0	0	0	80	0

Taxon Sampling time Sampling points	June 18 15	June 18 15/3	August 27 15	August 27 15/3	October 7 15	October 7 15/3
P. remata SKORIKOV	0	0	0	0	4 200	1 800
P. vulgaris CARLIN	22 000	700	1 500	1 600	17 000	1 200
Pompholyx sulcata HUDSON	0	0	1 800	0	160	0
Synthaeta grandis ZACHARIAS	29 000	0	0	0	0	0
S. pectinata EHRB.	14 000	0	0	0	12 000	0
Testudinella patina (HERMANN)	0	0	0	0	40	0
Trichocerca birostris (MINKIVICZ)	1 200	0	0	180	420	0
Tr. capucina (WIERZEJSKI U. ZACHARIAS)	0	0	270	140	130	0
Tr. dixon-nutalli (JENNINGS)	0	0	300	0	0	0
Tr. rattus (O. F. MÜLLER)	0	0	80	0	110	0
Tr. pusilla (JENNINGS)	0	0	180	0	0	0
TOTAL ROTATORIA:	314 300	2 500	18 130	9 760	62 250	15 510
CRUSTACEA						
Cladocera						
Alonella nana (BAIRD)	0	0	0	20	0	0
Bosmina longirostris (O. F. MÜLLER)	900	1 100	750	0	200	0
Ceriodaphnia pulchella SARS	0	4 000	0	0	0	10
Chydorus sphaericus (O. F. MÜLLER)	0	0	0	80	0	0
Daphnia longispina O. F. MÜLLER	0	24 000	0	0	0	0
Moina rectirostris (LEYDIG)	0	0	80	0	20	0
Pleuroxus aduncus (JURINE)	0	0	0	40	0	40
Scapholeberis mucronara O. F. MÜLLER	0	2 300	0	0	0	0
Simocephalus vetulus (O. F. MÜLLER)	0	1 900	0	0	0	10
Total Cladocera:	900	33 300	830	140	220	60
Calanoida						
Eudiaptomus gracilis G. O. SARS	0	450	0	0	0	0
Copepodit	0	100	0	0	0	0
Nauplius	0	0	0	400	0	0

Total Calanoida:	0	550	0	400	0	0
Cyclopoida						
Megacyclops viridis JURINE	0	400	0	0	0	0
Mesocyclops leuckartii CLAUS	140	1 500	0	0	0	0
Thermocyclops oithonoides G. O. SARS	0	0	190	360	0	0
Copepodit	4 800	2 000	3 200	400	450	1 500
Nauplius	430 000	44 000	21 000	5 900	16 000	3 800
Total Cyclopoida:	47 940	47 900	14 390	6 660	16 450	5 300
Total Crustacea:	48 840	81 750	7 200	16 670	5 360	*CCCCC*
Total Crustacea:	48 840	81 750	15 220	7 200	16 670	5 360
Rotatoria + Crustacea together:	363 140	84 250	33 350	16 960	78 920	20 870

In the experimental area, in June and July, the individual density of the Rotatoria approximated the conditions observed in fish-ponds in a similar period. In the wooded areas, the maxima of their individual numbers took place more than one month later, as compared to those observed in the open water, certainly owing to the food-competition of the Cladocera plankton and the consumption of the predatory Copepods. The October maxima developed after the destruction of the macrovegetation, and the December ones on the mass production of Synura uvella.

During investigating the Crustacea plankton, we have found 24 Cladocera, 1 Calanoida, 6 Cyclopoida, and 3 Ostracoda taxons.

The species number of Cladocera was high in the experimental area, their individual number was, however, very low, except for the initial period (Fig. 1). Some species of them *(Bosmina longirostris, Moina rectirostris)* were regularly found, their majority anyway only occasionally *(Alona rectangula, Alonella nana, Camptocercus lilljeborgi, Ceriodaphnia megops, Diapanosoma brachiurum, Macrothrix rosea)*, in some cases in considerable numbers *(Daphnia longispina, Scapholeberis mucronata, Simocephalus vetulus)*.

The plankton was populated in a considerably higher number by Cyclopoida. The well-developed individuals, with the exception of *Mesocyclops leuckartii,* and *Thermocyclops oithonoides,* were found in small numbers, but the number of the forms in phases copepodit and nauplius was considerable till the beginning of September (Fig. 1). The change in the density of the Cyclopoida plankton was following, in the majority of cases, the change in the individual number of Rotatoria.

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DATA TO THE HYDROBIOLOGY OF THE MIDDLE AND LOWER TISZA RIVER REGION

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Abstract

The investigations carried out in the Middle and Lower Tisza Regions have demonstrated the effects of the tributary Sajó and of the Kisköre River Barrage, as well as a change in the character of the river regions.

Introduction

The investigations of the longitudinal section are reflecting the state of water quality in the river, in accordance with the water motion. The effect of waters flowing into the river and that of damming, as well as the change in the character of the river regions, can be demonstrated.

The investigations of the longitudinal section are often performed by Tisza-researchers; the algological investigations were carried out by UHERKOVICH (1968, 1971), the zoological ones by MEGYERI (1957), JÓSA (1962), and GÁL (1961, 1966).

Material and method

The investigations in the Middle and Lower Tisza Regions were carried out in a lasting small-water period, at the end of March 1974. We have supposed that the reaches investigated contain similar water masses. We took therefore samples on the same day (March 22), fixing quasi the momentary state. The samples were taken from the current-line of the Tisza above the Sajó mauth (497 river-km), at Polgár (486 river-km), at Tiszakeszi (470 river-km), Tiszacsege (454 river-km), Tiszafüred (433 river-km), Tiszaderzs (415 river-km), Kisköre (404 river-km), Tiszaroff (380 river-km), Nagykörü (364 river-km), above Szolnok (335 river-km), at Csongrád (244 river-km), and at Tápé (177 river-km). The chemical investigations were carried out on the basis of a uniform standard ("VITUKI" 1970) and Felföldy's (1974) notices. The total bacterial count was performed with membrane filter method, the algological investigations according to Utermöhl's technique, the zooplankton investigation in a counting tube. The samples in Csongrád and Tápé were taken by the research workers of the Laboratory in Szeged and also the basic chemical investigation of these two samples was performed by these. We acknowledge with thanks their kind cooperation.

Results

During the investigation of the longitudinal section the weather was calm, windless, and sunny. The air temperature was rather warm for the season (9 to 27 °C), the temperature of the water surface rose slowly together with the rise in air temperature. In the morning we measured 8 °C, at noon 11.5 °C. In the course of the investigation, the water mass seemed to be slightly greenish in the whole sector.

The suspended matter content of the river was, in accordance with the character of water motion, low (17.4 to 23.6 mg/l), the water transparency was 50 to 60 cm. The dissolved oxygen and free carbon dioxide contents were of permanent value till the Kisköre River Barrage; in the reaches below the river barrage, however, we have observed a moderate increase in it. The mineral-substance content of the Tisza in the reaches investigated of the river did not change to a large extent, although below the Sajó mouth it is a little higher. The total phosphorus content has changed between 0.051 and 0.123 mg/l, the total nitrogen quantity was 2.756 to 4.286 mg/l. The mineral-nitrogen content has risen after the polluted Sajó and as a result of the industrial waters of Leninváros (cf.: Table 1).

The total bacterial count was comparatively low (6.12 to 11.34×10^6 ind./ml), and in the Tisza region investigated their number rose slowly. At the sampling point below the Kisköre River Barrage (Tiszaroff) the total bacterial count is regularly higher than before the river barrage (HAMAR 1975). MELNIKOV *et al.* (1973) demonstrated in the course of their investigations at the damming plants in the Dnieper that the bacterial count is 1.5 to 7.0 times higher in the sector after damming than above it. They have proved by means of experiments that a considerable part of microorganisms is destroyed by the strong current of water that goes with a multiplication of the microorganisms inducing the dissolution. The matters becoming available during their mineralization for algae promote the multiplication of these. In spite of the permanently low water output and damming, there couldn't develop any rich phytoplankton corresponding to the season. In the sector investigated we have found an association of 11 to 25 taxon-numbers. From the diatoms *Stephanodiscus tenuis* HUST., *Nitzschia acicularis* W. SMITH, *Asterionella formosa* HASSAL are the most frequent organisms, from the green algae *Ankistrodesmus falcatus* (CORDA) RALFS and *Ankistrodesmus falcatus* var. *setiforme* NYG., and from the Chrysophyta phyllum *Chrysococcus biporus* SKUJA are frequent (Table 2).

The species count in the reaches above the Sajó mouth is low (11). It can be followed till the end, how long the algae, that had got from the Sajó into the Tisza, are present there in the plankton. The phytoplankton of the Sajó is richer (20 taxons) and in the reaches below the Sajó mouth from the diatoms *Nitzschia palea* (KÜTZ.) SMITH and *Asterionella formosa* HASSAL, while from the green algae *Hyaloraphidium contortum* var. *tenuspinum* KORSCH. are the most considerable ones. The latter alga is heterotrophic and as many as several millions ind./l do appear in the bay of the Kisköre River Barrage at Abádszalók (HAMAR 1975*b*) as well as in the water of the experimental area near the river barrage (HAMAR 1975*c*). Even Chrysococcus biporus Skuja whose occurrence is so frequent in the Tisza, was getting from the Sajó to the Tisza (Table 2).

The change in the number of diatoms — mainly of *Stephanodiscus tenuis* HUST. — is characteristic of the quantitative dynamism. As a result of damming, the total algal count reaches its maxima at the Kisköre River Barrage, after that it falls. Later on, in the reaches at Tápé, the rise in number of the green algae is indicating the lower-reach character of the river (Fig. 1).

The total algal number of the eutrophic Sajó, charged with pollutions (VÁNCSA 1974, 1975) was similar to that of the Tisza at Kisköre. It appears from the quantitative analysis of algae that, in spite of the unfavourable climatic conditions, the Sajó

Table 2. *Phytoplankton of bay at Abádszalók late in the Autumn and in Winter* (10^3ind/l.)

Species	October 28		October 29		October 31		November 2		November 5		November 8		November 12		November 13		November 19		November 26		December 3		December 10		December 17	
	ind./l	%	ind./l	%	ind./l	%	ind./l	%	ind./l	%	ind./l	%	ind./l	%	ind./l	%	ind./l	%	ind./l	%	ind./l	%	ind./l	%	ind./l	%
Euglena viridis EHR.																							12			
Trachaelomonas volvocina EHR.	60		12										12													
Euglenophyta total	60	1,5	12	2,4	—		—		—						—		—		—		—		12	0,3	—	
Cryptomonas erosa EHR.	1320		60																60		300				60	
Cr. marssonii SKUJA	300																		60		24		120		60	
Cr. platyuris																					60		180		24	
Cr. pusilla BACH.	1020		12								12						12		180		1860		960		1500	
Cr. rufescens SKUJA	300		60								12		12						120		180		240		180	
Gymnodinium sp.	60																								12	
Pyrrophyta total	3000	78,9	132	26,8	—		—		—		24	6,7	12	3,4	—		12	1,7	420	29,4	2424	61,8	1500	41,3	1836	34,2
Chrysococcus biporus SKUJA	360		120		60		24						12						240		300		780		1680	
Mallomonas sp.																			12							
Synura uvella EHR.			60														12		60		60				60	
Chrysophyceae total	360	9,6	180	36,6	60	29,4	24	5,3	—		—		12	3,4	—		12	1,7	312	21,8	360	9,3	780	21,5	1740	32,3
Asterionella formosa HASSAL															12		24				60		60		24	
Cyclotella meneghiniana KÜTZ.			60				60												24							
Melosira granulata v. *angustissima* MÜLL.			12		60		60				60												12			
M. varians AGH.	12																									
Navicula cryptocephala KKÜTZ.											12															
Nitzschia acicularis W. SMITH	12														12				12							
Nitzschia spp.					12		120		60		12															
Stephanodiscus tenuis HUST.	12		60		60		60				120		12		12		120		180		120		240		420	
Synedra acus KÜTZ.											12						12									
Bacillariophyceae total	36	0,9	132	26,9	132	64,8	300	65,8	60	16,1	216	60,0	12	3,4	36	8,8	152	18,7	216	15,1	180	4,5	312	8,5	444	8,6
Ankistrodesmus acicularis (A. BR.)KORSCH.	12																									
A. falcatus (CORDA)RALFS	60						60				60															
A. longissimus (LEMM.)WILLE							60								60				24		180		180		480	
Crucigenia terapedia (KIRCH.)W. et G. S. WEST																	120		24		120				12	
Didymocystis planctonica KORSCH.	60																		60							
Elakatothrix gracilis HORTOB.									300				300		12				60							
Oocystis borgei SNOW	60														300		300		300		600		600		600	
Pediastrum duplex MEYEN																										
Scenedesmus ecornis (RALFS) CHOD.	60		12		12																		60			
Sc. denticulatus v. *linealis* HANGS.	24																						120			
Sc. intermedius CHOD.																							12			
Sc. quadricauda (TURP.)BRÉB.	60								12								12									
Selenastrum minutum																			12						12	
Tetrastrum glabrum (ROLL)AHL. et TIFF.			12																		60				60	
Chlorococcales spp.											60															
Chlamydomonas reinhardii DANG.																	60									
Closterium acutum BRÉB.	12		12				12										60						60		180	
Chlorophyta total	348	9,1	36	7,3	12	5,8	132	28,9	312	83,9	120	33,3	300	86,4	372	91,2	552	77,9	480	33,7	960	24,5	1032	28,4	1344	24,9
Total number of algae	3804	100	492	100	204	100	456	100	372	100	360	100	348	100	408	100	708	100	1428	100	3924	100	3636	100	5364	100

Table 2. *Phytoplankton data of the longitudinal-section investigation of the river Tisza (March 22nd 1974) 10³ind./l*

Species	Tisza above the Sajó 497 rkm		Sajó at its mouth		Tisza at Polgár 486 rkm		Tisza at T-keszi 470 rkm		Tisza at T.csege 456 rkm		Tisza at T.füred 433 rkm		Tisza at T-derzs 415 rkm		Tisza at Kisköre 404 rkm		Tisza at T.roff 380 rkm		Tisza at Nagykörü 364 rkm		Tisza at Szolnok 335 rkm		Tisza at Csongrád 244 rkm		Tisza at Tápé 177 rkm	
	ind./l	%	ind./l	%	ind./l	%	ind./l	%	ind./l	%	ind./l	%	ind./l	%	ind./l	%	ind./l	%	ind./l	%	ind./l	%	ind./l	%	ind./l	%
Lyngbia limnetica Lemm.																									60	
Microcystis sp.			6																							
Cyanophyta total	—		6	0,3	—		—		—		—		—		—		—		—		—		—		60	7,2
Euglena viridis Ehr.	12		36		12		6		6		6		6		6		6						18		24	
Trachaelomonas volvocina Ehr.	12				12		12		12						6								12		12	
Euglenophyta total	24	10,5	36	1,5	24	5,2	18	3,2	18	4,2	6	0,6	6	0,6	48	2,5	6	1,2	—		—		30	10,2	36	4,3
Chroomonas acuta Uterm.			12		6																					
Cryptomonas ovata Ehr.	18		48		6		6		6										18		18				6	
Cr. platyuris Skuja											6				6				12							
Cr. pusilla Bach.			18		30		6		6		6		6		30		12		42		24					
Gymnodinium sp.			6																							
Pyrrophyta total	18	7,9	84	3,5	42	9,1	12	2,	18	4,2	6	0,6	6	0,6	36	1,8	12	2,5	72	13,5	42	9,0	—		6	0,7
Chrysococcus biporus Skuja			6		6						12		18		24		12		6		30		6		30	
Ch. rufescens Klebs	6		24		12		6				24		6		30		18		30		24				12	
Chrysophyceae total	6	2,6	20	1,3	18	3,9	6	1,1	—		36	3,5	24	2,4	54	2,8	30	6,2	36	6,8	54	11,6	6	2,0	42	5,0
Asterionella formosa Hassal			90		6		18		6		78		48		54		6		12		6		6		6	
Cyclotella compta (Ehr.) Kütz.							6		6		12		6				6		6		6					
Diatoma elongatum (Lyng.) Agh.													6													
D. vulgare Bory	42				84		36		30		6		6				6		6		6					
Fragilaria capucina Desm.																	6									
Gomphonema olivaceum (Lyng.) Kütz.			12		6		6																			
Melosira distans (Ehr.) kÜTZ.					12				6		12														6	
Navicula cryptocephala Kütz.							6		6																	
Navicula spp.			24						6												6					
Nitzschia acicularis W. Smith	24		66		30		42		54		30		12		12		6		30		12		6		48	
N. palea (Kütz.) Smith			210		18		30				42		6		18				6							
Nitzschia spp.															12		12				12		6			
Stephanodiscus tenuis Hust.	42		780		73		198		132		630		660		1380		246		252		186		90			
Suriella ovata Kütz.			6				6		12				6		30		36		6		12		12		12	
Synedra acus Kütz.											6		12		6		6		6		12				24	
S. ulna (Nitsch.) Ehr.			198		18		24		12						6											
other diatoma spp.	24		42		18		6		12		18		12		18		6		12				12		18	
Bacillariophyceae total	132	57,9	1428	60,2	264	57,1	378	68,5	282	65,2	834	80,8	774		1536	79,8	336	69,2	330	62,7	263	56,3	132	44,9	114	13,7
Ankistrodesmus acicularis (A. Br.)																									6	
Korsch.																									12	
A. angustus Bern.															54		12						48		108	
A. falcatus (Corda) Ralfs			126		30		18				6		36		54		36		30		66		12		42	
A. falcatus v. setiforme Nyg.	6		108		12		36		18		54		36												6	
Chodatella quadriseta Lemm.																					6					
Crucigenia tetrapedia (Kirch.) W. et																										
G. S. West																							6		42	
Dictyosphaerium pulchel																										
Hyaloraphidium contortum v. tenuispinum																			6		6		12		30	
Korsch.			270		6		6		6																6	
Pediastrum boryanum (Turp.) Menegh.																									6	
Scenedesmus acuminatus (Lager.)Chod.													6													
Sc. acutus Meyen									6																6	
Sc. ecornis (Ralfs) Chod,			6								6															
Sc. intermedius Chod.											6				12								6		30	
Sc. quadticauda (Turp.) Bréb.																										
Sc. spinosus Chod.	6																									
Selenastrum minutum (Naeg) Collins																										
Tetrastrum elegans Playf.													12												66	
Tetrastrum glabrum (Roll) Ahl. et																										
Chlorococcales spp.															6										18	
Chlamydomonas reinhardii Dang.			6								6		12		30		12		42		30		24		66	
Chlamydomonas spp.	12		12		18		12		12		36		36		72		42		12				18		126	
Closterium acutum Bréb.	18		78		30		24		42		36		42		24											
Chlorophyta total	6		180		18		42		30																6	
Chlorophyta total	48	21,1	786	33,2	114	24,7	138	25,0	114	26,4	150	14,5	186	18,7	252	13,1	102	20,9	90	17,0	108	23,1	126	42,5	576	69,1
Total number of algae	228	100	2370	100	462	100	552	100	432	100	1032	100	996	100	1926	100	486	100	528	100	467	100	254	100	834	100

has an influence on the algological composition of the Tisza. The effect of damming on the increase in the algal count is proved by the quantitative results unequivocally.

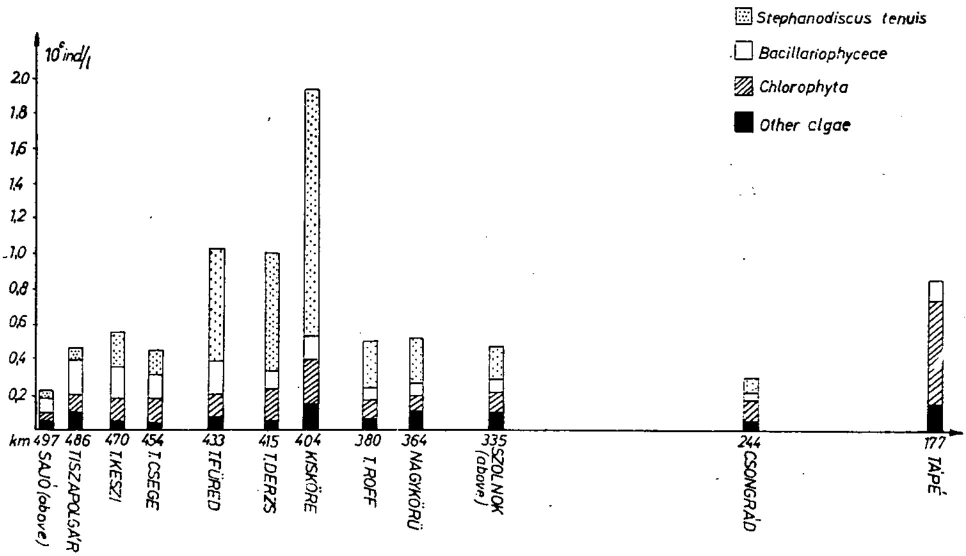

Fig. 1. Changes in the total algal count of the Tisza (March 22nd 1974)

In the course of our investigations so far (ÁDÁMOSI *et al.* 1974, VÉGVÁRI 1975) we observed that the suspended matter content of water is decreased by the winter and early spring dammings to minima but, because of the unfavourable climatic conditions, the maximum total algal number does not reach the values of the summer damming. As the food content is available during damming (B. TÓTH 1975), the alga stand of the river reaches between the Tisza sector above the Sajó mouth and the Kisköre River Barrage achieved the maximum tempo of increase corresponding to the temperature (GOLDMANN and CARPENTER 1974).

In the course of our investigations we found not more than two Zooflagellata species: *Monosiga ovata* KENT occurred in the Sajó and *Desmarella moniliformis* KENT in the Tisza at Tiszakeszi.

Corresponding to the early spring period, in the Rotatoria plankton of the Tisza the species occurring regularly in cold waters were dominant. Below the mouth of the Sajó (486 river-km), both the species and individual number were rising. The species occurring in a considerable number in the Sajó *(Epiphanes senta* O. F. MÜLLER, *Notholca squamula* O. F. MÜLLER, *Rotaria rotatoria* PALLAS*)* were found-in an essentially smaller quantity in the Tisza below the Sajó mouth, as well. The species *Epiphanes senta* O. F. MÜLLER that is characteristic of the polluted waters turned up, till Tiszafüred, from every sampling point. The individual density of Rotatoria was the greatest at the Kisköre sampling point above the river barrage, while in the sector below the barrage their quantity considerably decreased (Fig. 2).

In the course of the investigation of the longitudinal sector, the occurrence of the group Cladocera wa sunimportant. The Copepoda plankton was formed by the individuals in nauplius and copepodit state found in large numbers in addition to the few fully developed organisms. The individual density of the Cladocera and Copepoda planktons was not considerably influenced by the Kisköre damming (Table 3).

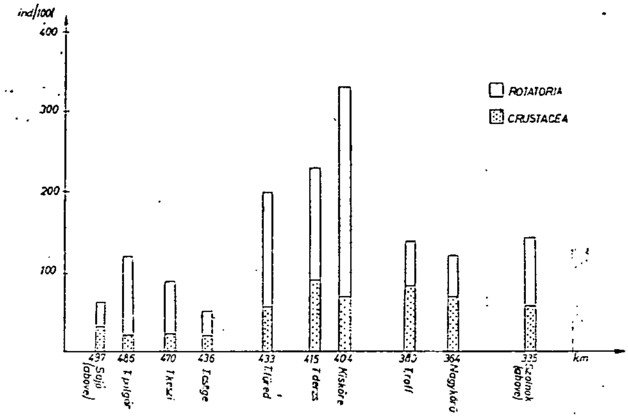

Fig. 2

It could be demonstrated in the course of our investigations that the character of plankton is influenced by the tributary (Sajó) and by the industrial pollutions, as well as changed by impoundment.

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Table 1. *Chemical results of the longitudinal section*

Sampling point	Tisza-above the Sajó mouth	Sajó at the mouth	Tisza Polg.	Tisza-keszi
Component	497	495	486	470
Weather	sun-schine, calm	sun-schine, calm	sun-shine, calm	sun-shine, calm
Degree of air temperature	9,0	9,0	21,0	4,5
Degree of water temperature	8,0	12,5	9,0	10,5
Colour	greenish	black-ish brown	greenish	greenish
Smell		smell-less		
Transparency mm	500	520	510	510
C.O.D.Mn mg/l	3,6	39,6	4,2	6,7
C.O.D.Cr mg/l	10,8	72,0	14,0	15,2
Dissolved O_2 mg/l	11,5	4,8	11,1	10,3
Oxygen saturation mg/l	97,1	45,3	96,1	92,4
*p*H	7,3	7,4	7,5	7,5
Conductivity	430	1006	371	387
"m" alkalinity	2,5	4,8	2,5	2,6
Total hardness, int	7,8	16,1	7,8	8,0
Carbonate hardness, int.	7,0	13,4	7,0	7,3
Ca^{2+} mg/l	36,9	94,6	37,7	41,7
Mg^{2+} mg/l	11,1	12,3	11,2	9,2
Na^+	51,5	85,0	54,0	55,2
K^+	7,5	23,5	9,6	8,0
Cl^-	23,8	63,8	26,7	29,5
Son 4^{2-}	15,1	57,3	22,2	25,4
HCO_3	152,6	292,9	152,6	158,7
Free CO_2 mg/l	2,8	10,8	2,9	2,8
Fe^{2+}	1,459	1,741	1,348	1,348
NH_4^+	0,481	12,966	0,666	1,128
NO_2^-	0,120	0,720	0,142	0,180
NO_{3-}	8,363	4,838	8,815	6,235
$Po_4\ 3^-$	0,044	0,394	0,044	0,061
Total dissolved matter mg/l	190	488	241	228
Total suspended matter mg/l	210	15	21,8	23,6
Total dry matter mg/l	20	503	263	255
Dissolved orthophosphate P mg/l	0,014	0,128	0,014	0,019
Dissolved non-reactive P mg/l	0,043	0,015	0,029	0,038
Total disolved P	0,057	0,143	0,043	0,057
Formed P mg/l	0,022	0,008	0,008	0,020
Total P mg/l	0,079	0,151	0,051	0,077
Nitrate-N mg/l	1,889	1,093	1,991	1,408
Nitrite N mg/l	0,037	0,819	0,043	0,055
Ammonium-N	0,368	9,897	0,507	0,859
Free ammonium-N mg/l	0,005	0,171	0,010	0,017
Inorganic-N mg/l	2,299	11,380	2,551	2,339
Kjeldahl-M mg/l	1,961	11,174	1,666	1,293
N of organic bond mg/l	1,588	1,106	1,149	0,417
Total N mg/l	3,887	12,486	3,700	2,756

investigation of the Tisza (March 22nd 1974)

Tisza-csege	Tisza-füred	Tisza-derzs	Kisköre	Tiszaroff	Nagy-körü	Szolnok above the Zagyva	Tápé	Csongrád
456	433	415	404	380	364	335,4	177	246
sunny, calm	sunny, calm	sunny, calm	sunny, calm	sunny, calm	starry sky, calm	starry sky	sunny	sunny
22,5	27,0	25,5	24,5	19,0	14,5	14,2	24,0	17,0
10,5	11,5	9,5	9,5	9,5	10,0	9,5	13,8	11,2
greenish	greenish	greenish	greenish	greenish	—	—	yellow	yellow-grey
600	600	600	600	480	immeasurable		147	160
5,8	5,6	5,5	6,5	5,8	5,2	6,0	5,0	3,5
20,4	18,0	17,2	18,0	15,2	13,2	12,4	22,0	21,0
10,7	10,5	10,2	10,4	11,1	11,2	11,1	11,9	11,0
96,0	96,6	89,4	91,1	97,3	99,4	97,3	115,0	100,0
7,5	7,6	7,5	7,5	7,5	7,5	7,6	7,5	7,6
364	387	364	371	333	348	340	410	390
2,5	2,6	2,5	2,6	2,5	2,5	2,5	2,45	2,26
7,7	8,2	7,8	8,3	8,1	8,1	8,4	8,8	8,3
7,0	7,3	7,0	7,3	7,0	7,0	7,0	6,9	6,3
40,1	43,3	40,9	42,5	43,3	44,1	44,9	47,0	42,0
9,2	9,2	9,2	10,2	8,8	8,1	9,2	9,7	10.0
55,5	56,0	38,5	39,0	54,0	49,0	45,5	20,0	18,0
8,5	9,0	5,0	5,0	8,0	7,5	8,0	7,5	8,0
28,6	28,6	26,7	26,7	23,8	22,9	23,18	31,0	29,0
20,5	21,9	22,7	25,3	22,1	20,5	21,8	51,0	29,0
152,7	158,6	152,6	158,6	152,6	152,6	152,6	150,0	138,0
2,6	2,0	2,8	2,6	3,0	3,1	3,1	2,0	2,0
1,179	1,100	1,010	0,954	1,291	1,101	1,126	0,030	0,025
0,925	1,165	0,758	1,109	0,925	0,925	0,869	1,50	1,60
0,158	0,165	0,151	0,180	0,112	0,128	0,128	0,14	0,13
7,310	7,632	7,955	8,600	8,062	8,600	6,772	7,000	7,000
0,044	0,041	0,061	0,044	0,044	0,044	0,044	0,16	0,130
196	208	117	204	198	189	194	285	270
21,8	19,2	20,4	18,8	21,0	17,4	19,0	40,0	55,0
218	227	137	223	210	206	213	325	325
0,014	0,014	0,019	0,014	0,014	0,014	0,014	—	—
0,052	0,043	0,015	0,029	0,009	0,014	0,086	—	—
0,071	0,057	0,034	0,043	0,020	0,028	0,100	—	—
0,020	0,022	0,017	0,008	0,002	0,023	0,023	—	—
0,091	0,079	0,051	0,051	0,022	0,051	0,123	—	—
1,651	1,724	1,797	1,943	1,821	1,943	1,530	—	—
0,048	0,050	0,048	0,055	0,034	0,039	0,039	—	—
0,704	0,885	0,576	0,845	0,704	0,704	0,660	—	—
0,014	0,020	0,012	0,017	0,014	0,014	0,015	—	—
2,417	2,679	2,433	2,860	2,573	2,700	2,244	—	—
1,924	1,982	2,441	1,723	1,579	1,551	1,579	—	—
1,206	1,077	1,853	0,861	0,861	0,833	0,904	—	—
3,623	3,756	4,285	3,721	3,434	3,533	3,148	—	—

Table 3. *Rotatoria and Crustacea data of the longitudinal-section investigation of the Tisza (March 22nd 1974), (ind/100 l)*

Species	Tisza above the Sajó 497 rkm	Sajó at its mouth	Tisza at Polgár 486 rkm	Tisza at T.keszi 470 rkm	Tisza at T.csege 456 rkm	Tisza at T. füred 433 rkm	Tisza at T.derzs 415 rkm	Tisza at Kisköre 404 rkm	Tisza at T.roff 380 rkm	Tisza at Nagykörü 364 rkm	Tisza at Szolnok 335 rkm
ROTATORIA											
Brachionus angularis Gosse								16	6	2	6
Br. calyciflorus var. *dorcas* f. *spinosa* (WIERZEJSKI)				4		2	2				
Br. leydigi var. *quadratus* (ROUSSELET)		4					6	6			
Br. urceolaris O. F. MÜLLER	4	28	6	2	4						
Br. quadridentatus var. *brevispinus* (EHRB.)							16	4			
Euchlanis dilatata EHRB.							4				
Epiphanes senta (O. F. MÜLLER)	4	56	4	6	6	6					
Filinia longiseta (EHRB.)								4			
Kellicottia longispina (KELLICOTT)	4							6			
Keratella cochlearis cochlearis GOSSE			4	6	4	4					
K. cochlearis var. *machracantha* LAUTERBORN		18	4								
K. cochlearis var. *macracantha* f. *micracantha* LAUTERBORN						8	18	70	16	8	14
K. quadrata (O. F. MÜLLER)		26	2		2	14	18	18	8	6	8
Notholca acuminata (EHRB.)		8	8				12				
N. squamula (O. F. MÜLLER)		100	16	14		38		24			24
Polyarthra longiremis CARLIN		12		8	4	10	26	48	24	24	36
Rotaria rotatoria (PALLAS)	8	780	58	10	4		14		12		
Synchaeta grandis ZACHARIAS				28	10	38	6			12	
S. oblonga EHRB.	12					26		36			
Total Rotatoria:	32	1032	102	78	34	146	122	232	66	52	88

CRUSTACEA											
Cladocera											
Chydorus sphaericus O. F. MLÜLER							2				
Total Cladocera:	—	—	—	—	—	—	2	—	—	—	—
Calanoida											
Eudiaptomus gracilis G. O. SARS	4				2				2		44
Nauplius	8				4			6	28	16	10
Total Calanoida:	12	—	—	—	6	—	—	6	30	16	54
Cyclopoida											
Cyclops strenuus Fischer							2				
Eucyclops speratus LILLJEBORG				2							
Copepodit				4		8	6	8	14	8	
Nauplius	18	48	20	14	14	46	76	52	38	42	
Total Cyclopoida:	18	48	20	20	14	54	84	60	52	50	—
OTHER ORGANISM											
Nematoda spp.	6	2800	18	60	22	24	—	—	—	—	—

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HYDROECELOGICAL INVESTIGATIONS IN THE BAY OF THE FUTURE KISKÖRE RESERVOIR AT ABÁDSZALÓK

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(Received 30 June, 1975)

Abstract

The paper is analysing the hydrobiloogical processes to be taken place in the bay of the future Kisköre Reservoir at Abádszalók.

The conditions to come after the reservoir being filled up may be inferred from the processes taking place in the bay durably overflowed by the inundation.

Introduction

The bay of about 12 sq.km surface at Abádszalók was filled up at the inundation of the Tisza in Summer and Autumn, 1974. The water surface nearly reached the water level of the future Kisköre Reservoir. In this way, an open-water surface of four metres or so was produced. About the biological investigations carried out, detailed analyses were given by BANCSI (1975) and HAMAR (1975). The bay and the flooding Tisza in the Kisköre profile were investigated parallel (Fig. 1).

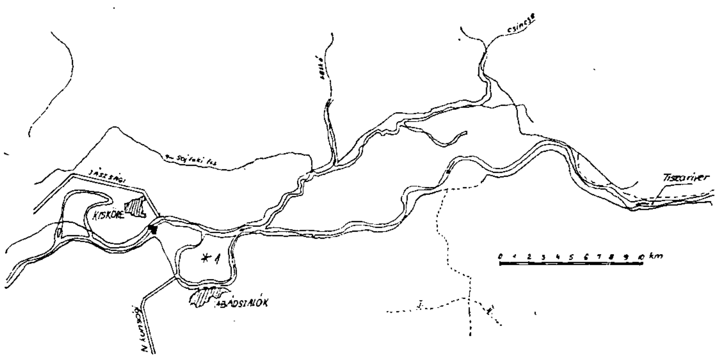

Fig. 1. Kisköre Reservoir and the bay at Abádszalók — Sampling point.

Characterization of the area investigated, material and method

From the beginning of June till August the 3rd and from the beginning of October till the beginning of December in 1974, there was a considerable flood in the Tisza. As a result of the two largest flood-waves since the great Tisza inundation in 1970, on June the 26th at Kisköre the water level of the Tisza reached the A. O. D. 89.97, and on November the 4th it reached the A. O. D. 90.20 that was hardly lower than the planned damming surface of the Kisköre Reservoir. The flood-plain was inundated by the coming water masses, about 80 per cent of the future reservoir has got under water. As a result of a strange play of the nature, therefore, the reservoir was filled up what was expected by us only after four years, in 1978, on the occasion of filling the reservoir planned.

The initial formation of the quality of the water stored was followed with attention in a characteristic part of the reservoir, in the bay at Abádszalók. The Abádszalók-bay is lying in the part of the reservoir between Kisköre and Abádszalók, at a surface of about 12 sq.km (Fig. 1). The average water depth is 3.5 to 4 m, its covering with land vegetation is similar to that of the whole reservoir, the predominating wind direction is from the west, north-west.

The Tisza-backwater found at Abádszalók will certainly be considerable because of its micro- and macrovegetation after its being filled up, as well as owing to the distribution and "stabilization" of the microfauna.

The investigation of the chemical and biological changes in the bay at Abádszalók was carried out from July the 3rd till August the 27th and from October the 23rd till December the 17th, in the beginning more frequently (every one or three days), then with a weekly frequency, at a sampling point. Our investigations had been accomplished before isolating the various water surfaces of the bay.

For the chemical investigations we dripped out 5 l sample, and performed the determinations according to the "COMECON" Uniform water-research methods 1970, issued by the VITUKI (Water Research Institute), and on the basis of Felföldy's Biological water qualification (1970). The biological investigations are specified in the papers of BANCSI (1975) and HAMAR (1975).

Results of the investigations in the summer period

The most striking of the physical changes is the change in the suspended load content of water. In the period after inundation the concentration of the suspended matter suddenly decreased and fluctuated between 8.6 mg/l and 18.6 mg/l. In that period, values of about 550 mg/l were measured in the Tisza.

In the course of an aerial survey, we have observed a well-perceptible difference between the water-colours of the Tisza and the flood-plain. In the greenish and yellowish-green water of the flood-plain the line of the yellowish-brown, troubled water of the river stood out in a sharp contrast to it.

The temperature of water has developed in the bay at Abádszalók according to the weather and season.

The waves of often one metre height, originating as a result of the frequently very strong north-west winds, threw the remains of land vegetation floating in the water, as well as the broken fragments, on the slope of the dam at Abádszalók. In the river-side bars we have found a large amount of cereals, too, uprooted by the strong waves from the agricultural area lying 4 km far from the dam and washed away on the bank.

The water of the bay at Abádszalók was, like that of the Tisza, beta-alpha oligohalobic, of Ca—HCO_3-type, in the whole period of the investigation. In its inorganic chemical composition there was no essential change to be found. The slow increase in its total salt content is referring to the growing concentration of water that followed from the very intensive evaporation.

On the basis of the summer investigations, there were separated five characteristic periods of the processes taking place in the bay.

In the initial period (from July the 3rd to the 9th), the mineralization of land-vegetation (plants at grass-level) and that of the organic components of the suspended matter commenced with a surprising speed. Then we observed the rapid increase in number of the catabolic bacteria and simultaneously, the rise in concentration of the dissolved orthophosphate and nitrogen of inorganic bond that meant a concentration of the food available for autotrophic organisms (Figs. 2, 3). In the water cleared, the development of the microvegetation became intensive, engendering an increase in the concentration of the nitrogen of organic bond. In the period of mineralization, therefore, the increase in the total nitrogen content was characteristic. The high total nitrogen content was a result of the amount of forms partly existing in the water from the beginning, partly dissolved from the decomposition of the land vegetation having remained in the area, as well as from the bottom of the river bed (Figs. 2, 3).

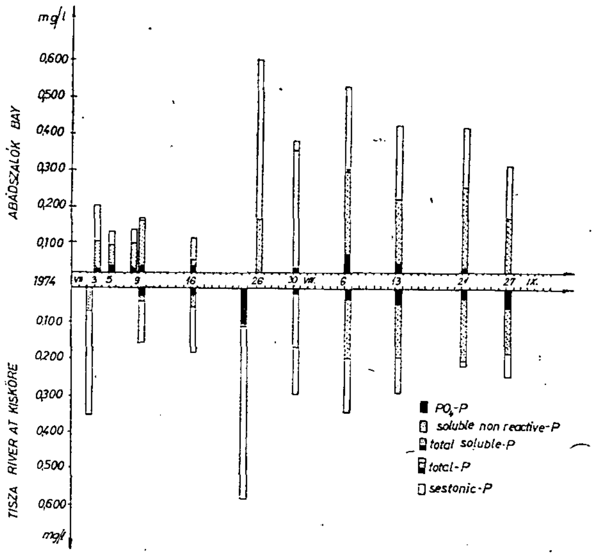

Fig. 2. The dynamism of phosphorus forms in the Kisköre profile of the Tisza and the bay at Abádszalók, in the period of the summer inundation in 1974.

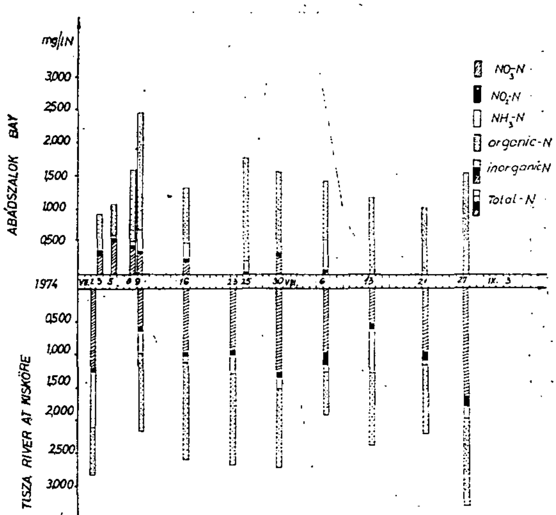

Fig. 3. The dynamism of nitrogen forms in the Kisköre profile of the Tisza and the bay at Abádszalók, in the period of the summer inundation in 1974.

Of the second period (from July the 9th to the 16th) the sudden development of the phyto-and zooplankton was characteristic. The decreasing intensity of the decomposition of the organic matter was indicated by the decrease in the total bacterial number, and the increase in the degree of trophity by the quick multiplication of algae. The overmultiplication of the microvegetation was restricted by the amount of the available food. In this period began the decrease in the nitrogen content of inorganic bond. The multiplication of zooplankton on the existing phytoplankton continued, its overmultiplication however could not follow, either, owing to the limited amount of food (Figs. 2, 3).

In the third period from July the 16th to August the 6th) the decrease in food supply resulted in the decay of phytoplankton, and then in that of zooplankton. The mineralization of the individuals perished was indicated by the rise in the total bacterial number but the food released in that way was built into the phytoplankton already but in a minor amount, its larger part was transported towards the macrovegetation, appearing and spreading more and more. As a result of that, we were witnesses of the appearance and distribution of *Schoenoplectus lacustris* (L.) PALLA and *Polygonum amphybium* L. (Fig. 6).

Of the fourth period (from the 6th to the 21st of August), the comparative sta-

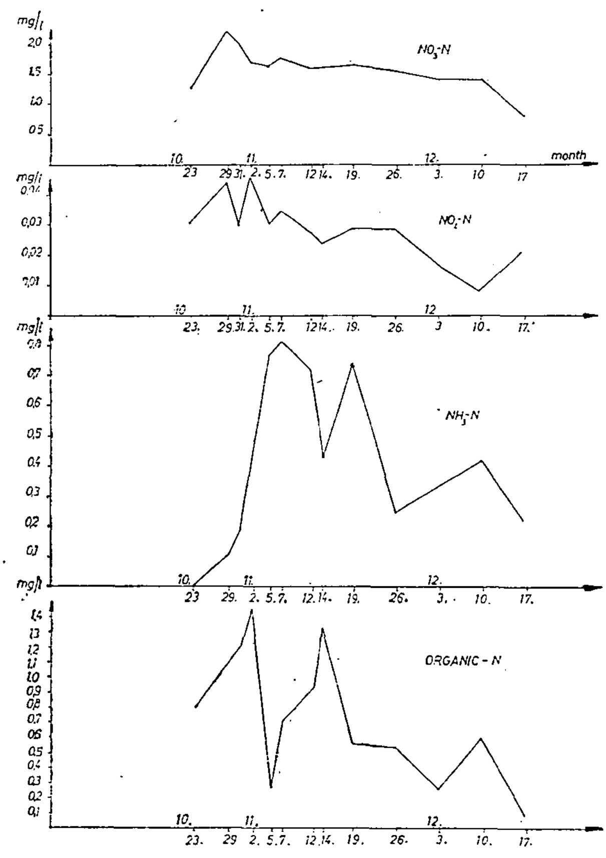

Fig. 4. Formation of the nitrogen forms in the bay at Abádszalók, in the time of the autumn inundation.

bilization of the microvegetation and microfauna was characteristic. The amount of the phyto- and zooplankton did not change essentially but the qualitative combination is different. The inorganic food, released from the organic matters that are not easily dissociable and that dissolved from the soil, infiltrated into the more and more prevailing macrovegetation. The amount of the nitrogen of inorganic bond in the water did not reach the limit of demonstratibility. In this period, the concentration of the total nitrogen was given by the amount of the nitrogen of organic bond in the phyto- and zooplankton, moving at an approximately constant value (Figs. 2, 3).

The fifth period (from August the 21st to the 27th) was the result of the flood passed. The decrease in water level was not favourable to a further development of macrovegetation. Its gradual decay and mineralization made possible a repeated rise in the amount of the phyto- and zooplankton. To further observations and investigations the isolation of the various water surfaces has put a stop after the flood had passed.

On the occasion of a local survey on September the 3rd, we observed alocal alga bloom at the single water surfaces (Hamar 1975).

Results of the investigations in the autumn-winter period

We investigated the bay from October the 23rd till December the 17th, when, the water was frozen over, in the flood-plain inundated on the occasion of the autumn flood repeatedly, at the same sampling point as in Summer.

In accordance with the season, the water temperature decreased more and more, being initially 7 °C, then on December the 17th 0 °C at the surface.

The period of investigation was characterized by a strongly windy, cloudy and foggy weather. In the beginning, the colour of water was "blond", characteristic of the "yellow" Tisza, on November the 5th, however, it was greenish-yellow, later on greenish, and at last opaline green. Transparency that was 25 cm at sampling, increased more and more, achieving the maxima (70 cm) on November the 26th. That was followed by the 20 ot 25 cm values of the opaline green water.

The mineral matter content of the water of bay did not changed considerably in this period. Oxygensaturation was between 70 and 90 per cent, the amount of free carbon dioxide 3 to 7 mg/l. The values of the C. O. D. (chemical oxygen demand) measured with potassium permanganate were lower than those measured in the Tisza.

The fluctuations of the autumn flood, the sedimentation following that and later the whirling effect of the wind are accurately reflected by the changes in the amount of the suspended matter, of the nitrogen and phosphorus forms (Figs. 4, 5). The relative constancy of the nitrogen content of inorganic bond is a result of the balanced functioning of reducent and producent organisms. The dissolved orthophosphate decreased in the descending branch of the flood-wave, and its quantity was periodically zero (Fig. 5). In its disappearance the colloids must have had a part, as well.

By investigating the bay at Abádszalók, we have obtained some results giving us some informations on the changes in the water quality in the period after filling up the reservoir.

On the basis of the observations and results of the investigation it may be established that in forming the water quality of the reservoir, the direction and strength of the wind and the waves induced by that have a very large part.

Halobity, *i. e.*, the sum of the inorganic chemical factors of water, that is important in biological respect, has not changed essentially.

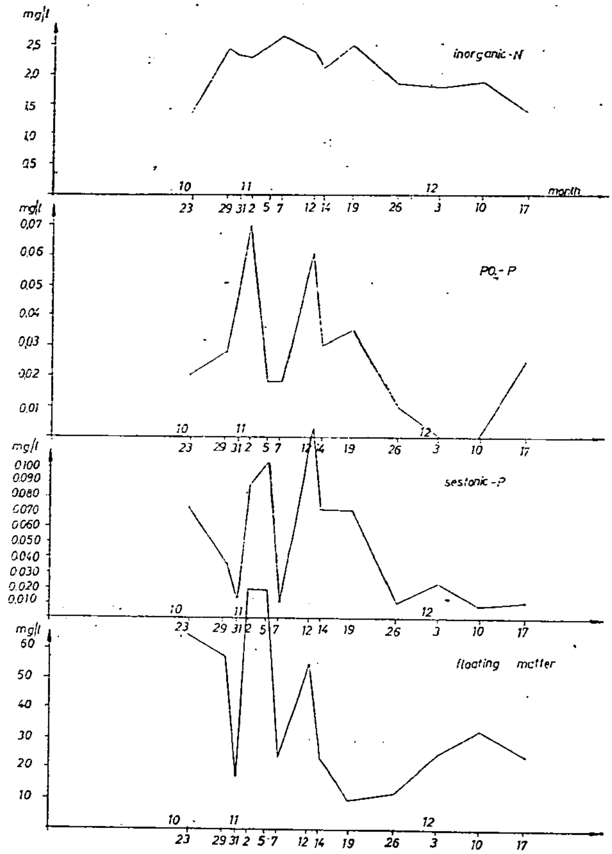

Fig. 5. Formation of the suspended matter content and of some chemical components bound to it in the bay at Abádszalók, in the period of the autumn inundation.

In respect of saprobity and trophity, however, we have already observed very essential changes, that can possibly be brought into connection with the dissolution of the organic and inorganic matters of the soil, as well as with the mineralization of the land vegetation remaining in the riverbed.

It is proved both with the summer and the autumn-winter investigations that a quick utilization of the food supply in the Tisza is made possible by the backwater conditions formed (B. Tóth 1975, Végvári 1975), enabling the beginning of a very intensive biological life, following the decomposition of the land vegetation left in the riverbed. By reason of the results it is to be expected that the water of the reservoir will be eutrophic.

It is proved by the very high individual and species numbers found in the course of the biological investigations, by the comparative stability of the plankton developed in the fourth period, by distribution of the marshy vegetation and reed-grass, that the natural history of Kisköre Reservoir will be determined fundamentally first of all not by a fortuitous settling but certainly by the micro- and macrofauna, as well as macroflora, living at present in the backwaters and borrow area of the flood-plain, overflowed by the water of the Tisza.

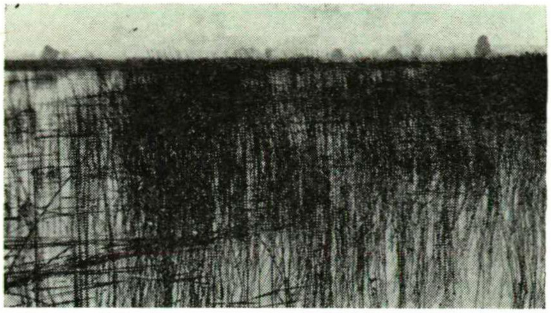

Fig. 6. The well-developed stand of *Schoenoplectus lacustris* (L.) PALLA.

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BACTERIOLOGICAL AND ALGOLOGICAL INVESTIGATION OF THE BAY AT ABÁDSZALÓK (KISKÖRE RESERVOIR)

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(Received 30 June, 1975)

Abstract

The paper is showing the bacteriological and algological results of the investigations concerning the future Kisköre Reservoir oberflowed by inundations.

Introduction

The major inundations of the Tisza fill up the future Kisköre Reservoir and even after the flood had passed, some larger isolated water spaces are left over. In 1974, we carried out on two occasions the investigation of the — about 12 sq.km large — bay at Abádszalók, filled up from the Reservoir by the summer and autumn floods. Owing to the peculiar situation of the bay, after its being filled, the alluvial Tisza water flowing at one end of it did not mix with the water of the bay. The bay water has clarified in spite of the flooding river and the two water types could be compared with each other. In addition to the bacteriological and algological investigations we performed hydrochemical (VÉGVÁRI *et al.* 1975) and zoological (BANCSI 1975) investigations, as well.

Method

The examination of the total bacterium number was carried out with membrane-filter procedure (FELFÖLDY 1974). At counting *Planctomyces bekefii* GIM. and at the algological investigations we applied Utermöhl's technique. The measuring of chlorophyll content took place with methanol solution (FELFÖLDY 1974). The surface samples were taken from the middle of the bay of about four metre depth. The total bacterium number was carried out by I. BANCSI, the determination of chlorophyll content by MÁRIA B. TÓTH, and placed at our disposal. I wish to express my thanks to them for their generous help.

Results

The investigation of the summer flood, and the period following that, lasted from July the 2nd till August the 27th. In spite of the intensive biological life, the total bacterium number (9 to 28 million ind./ml) was lower in the bay than in the flooding Tisza (17—80 million ind./ml) because the suspended matter of the flooding Tisza comes from soil erosion and has, therefore, a high organic-matter content.

Planctomyces bekefii GIM., that indicates eutrophic water (HAMAR 1975), was missing from the flooding Tisza during the two mounths investigated; at the same time, it often occurred in the bay in an order of magnitude of several millions. At the inundation of the bay the individual number of *Planctomyces* is high (2.5 million ind./l), later it decreases, increasing again only at the subsequent isolation of the water space (4.8 million ind./l).

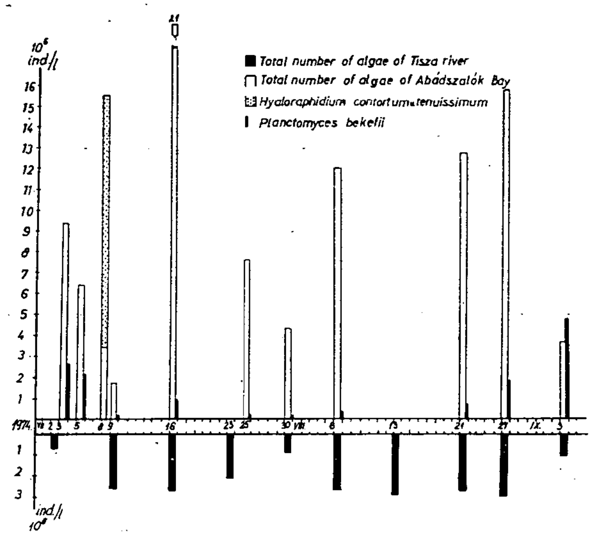

Fig. 1. Dynamism of the algae of the Tisza and of the bay at Abádszalók
Total alga count of the Tisza
Total alga count of the bay at Abádszalók

In the bay filled in with the water of the flooding Tisza, a quick change in the algal stand of river water took place as a result of the slower water motion and the silting of the suspended matter (VÉGVÁRI 1975). The summer limnoplanktonical stand is similar to that found in the impounded Tisza at the Kisköre River Barrage in the time of summer damming (HAMAR 1975). At the same time, in the water of the flooding Tisza, flowing at one end of the bay, a potamoplanktical stand of low species and individual number was found (Fig. 1, Table 1).

The number of alga taxons is of the following distribution:

	Bay at Abádszalók	Tisza
Cyanophyta	6	2
Euglenophyta	9	3
Pyrrophyta	8	4
Chrysophyceae	10	3
Bacillariophyceae	14	10
Chlorophyta	31	17
Total	78	43

The most characteristic species are: *Nitzschia acicularis* WW. SMITH, *Stephano-*

discus tenuis HUST., *Chrysococcus biporus* SKUJA, *Ankistrodesmus falcatus* (CORDA) RALFS, *Ankistrodesmus acicularis* (A. BR.) KORSCH. In the initial period also the species inducing algal bloom were present, as *Aphanizomenon flos-aquae* (L.) RELFS, *Microcystis aeruginosa* KÜTZ., *Euglena proxima* DANG. (Table 1). There occurred some rare species, as well: *Achronema articulatum* SKUJA, living in strongly polluted waters (HAMAR 1970—1971), *Chroomonas acuta* GEIT., *Cryptomonas marssonii* SKUJA, *Cryptomonas platyuris* SKUJA, *Cryptomonas pusilla* BACH., *Chrysidalis peritaphrena* SCHILLER, *Dinobryon elegantissimum* (KORSCH.) BOURR., *Dinobryon suecicum* LEMM., *Kephyrion tubiforme* FOTT, *Rhizosolenia longiseta* ZACH.

In the dammed bay, the suspended matter settled, the food content of the Tisza water became available and together with the food dissolved from the soil it assured the quick development of phytoplankton. In this way, the initial total alga number of the bay (July 3) is 9.3 million ind./l, with the dominance of green algae (62.1 p. c.) and diatoma (26.3 p. c.). Later on, the decrease in alga number was broken by the high individual number (12 million ind./1) of a colourless green alga: *Hyaloraphidium contortum* var. *tenuispinum* KORSCH., showing thus the heterotrophic way of feeding pushing forward (78 per cent of the total alga number). The decrease in algal number (July 9) is followed by an explosion-like invasion (July 16), the total alga number is 21.6 million ind./1, with the dominance of *Ankistrodesmus facatus* (CORDA) RALFS, *Chrysococcus biporus* SKUJA, and *Nitzschia acicularis* W. SMITH. Later on, in the course of the investigation period, the algal number was varying high (3.7 to 15.7 million ind. /l)invariaby with the dominance of green algae and diatoma.

After the flood the water of bay was isolated and the considerable sinking of the water level induced food-concentration and algal bloom. We have observed the algal bloom of the blue algae *Anabaena flos-aquae* BRÉB. On the bottom dried, we have found *Cladophora* and *Spirogyra* fields among the dense stands of *Schoenoplectus lacustris* (L.) PALLA that developed in the meantime explosion-like.

The change in the chlorophyll content is similar in its tendency to the dynamism of algae. The initial high value (67 mg/cc.m) quickly declines (16—18 mg/cc.m), then it shows permanently a high value (47—154 mg/cc.m). At the same time, the values of the Tisza measured simultaneously reach maximum 20 mg/cc.m, but generally they are lower (4—10 mg/cc.m).

In Autumn, the bay was inundated again. The investigation of the autumn flood and of the winter period following that lasted from October the 23rd till December the 17th. The total bacterium number of the flooding Tisza and flooded bay was high (120 million ind./ml or so). After the sedimentation following the flood, the values are lower (70—40 million ind./ml). In the winter water of the isolated bay (December 17) the bacterium number was unusually high (294 million ind./ml). *Planctomyces bekefii* GIM. did not occur in the period investigated.

In the flooded bay and the flooding Tisza, as well, the total algal count is low (Table 2).

After the sedimentation of the suspended matter, in spite of the winter period, there developed an algal stand of high number (on December 17th: 5.3 million ind./l). The limnoplanktonical elements dominated. The individual count of *Chrysococcus biporus* SKUJA, *Cryptomonas pusilla* BACH., and *Stephanodiscus tenuis* HUST. is considerable. The tendency of the total algal count is followed by the changes in the chlorophyll content.

It is shown by the investigation of the flood-induced alluvial deposit in the area of the future reservoir that, after the actual sedimentation, the eutrophic state will be materialized to all probability.

Table 1. *Summer and early-autumn*

Species	July 3 ind./l	%	July 5 ind./l	%	July 8 ind./l	%	July 9 ind./l	%
Achronema articulatum SKUJA	30							
Aphanocapsa elachista W. et G. S. WEST			6				60	
Aphanizomenon flos-aquae (L.)RALFS	60		60		60		12	
Lyngbia limnetica LEMM.			30					
Microcystis aeruginosa KÜTZ.	30							
Oscillatoria spp.							30	
Cyanophyta total	120	1,3	96	1,5	60	0,4	102	6,0
Euglena acus EHR.								
E, proxima DANG.	60		30		6			
Lepocinclis fusiformis (CARTER)LEMM.								
L. texta v. *salina* (FIRTSCH)POPOVA								
Phacus parvulus KLEBS								
Phacus spp.								
Strombomonas fluviatilis (LEMM)DEFL.								
Trachaelomona hispida v. *marcopunctata* SV.	6		60				6	
Tr. hispida v. *punctata* LEMM.	6		24					
Tr. volvocina EHR.	60		60				30	
Trachaelomonas spp.								
Euglenophyta total	132	1,4	174	2,7	6	0,04	36	2,2
Chroomonas acuta UTERM.								
Cryptomonas erosa EHR.	270							
Cr. marssonii SKUJA	60							
Cr. ovata EHR.	300						6	
Cr. platyuris SKUJA								
Cr. pusilla BACH.			6					
Ceratium hirundinella (O. F. MÜLLER)BERGH								
Gymnodinium sp.	6				12			
Periidinium aciculiferum LEMM.			6					
Pyrrophyta total	636	6,8	12	0,2	12	0,1	6	0,4
Chrysidalis peritaphrena SCHILLER	90		6					
Chrysococcus biporus SKUJA			30				30	
Dinobryon bavaricum IMHOF								
D. elegantissimum (KORSCH.)BOURR.	30		6		6			
D. divergens IMHOF	30							
D. suecicum LEMM.	30							
Kephyrion tubiforme FOTT			30					
Mallomonas caudata IVANOFF	6		30		60			
Synura uvella EHR.	6		30					
Chrysophyceae total	192	2,1	132	2,0	66	0,4	30	1,8
Asterionella formosa HASSAL	30		6		6			
Atteya zachariaschii BRUN					6			
Cyclotella compta (EHR.)KÜTZ.	30		30				12	
C. meneghiniana KÜTZ.	150		120		60		90	
Melosira distans (EHR.)KÜTZ.	30		6					
M. granulata v. *angustissima* MÜLL.	150							
Nitzschia acicularis W. SMITH	1200		930		300		180	
N. actinastroides (LEMM.)GOOR	180		120		90			
N. palea (KÜTZ.)SMITH	30		12					
Nitzschia spp.	210		210		180		30	

phytoplankton in the bay at Abádszalók (10^3ind./l)

July 16 ind./l	July 16 %	July 25 ind./l	July 25 %	July 30 ind./l	July 30 %	August 6 ind./l	August 6 %	August 21 ind./l	August 21 %	August 27 ind./l	August 27 %	September 3 ind./l	September 3 %
						60				30			
						60		180		180		90	
										30			
120		30				120		30		90			
				30						36		6	
120	0,6	30	0,4	30	0,7	240	2,0	210	1,7	366	2,3	96	2,6
						30				390		60	
90		60		12		330		240		510		30	
										240			
60				120		90				120		30	
						120		210				90	
						90				270			
60										120			
				12		30		60		30			
6				30									
220				120		840		1350		1440		390	
120		30		120		30		150		510			
1056	4,9	90	1,2	414	9,6	1560	13,0	2010	15,8	3620	23,0	600	16,1
		60		60									
30		60				60							
120		390				150						150	
90		540		120		180		90				30	
		30										6	
						90							
												6	
6				30		30						30	
												30	
246	1,1	1080	14,2	200	4,6	510	4,3	90	0,7	—		252	6,8
								30					
3450		570		330		1380		1620		2100		540	
										180			
				30		30				180			
				30						240			
				30						30			
3450	16,0	570	7,5	420	9,7	1380	11,4	1650	13,2	2730	17,4	540	14,5
				60								6	
				30									
60				120				30					
										30		270	
		6				30		30					
3000		1320		480		300		450		120		60	
				60				90					
		30		30		30							
180		570		120		540		420					

Table 1.

Species	July 3 ind./l	July 3 %	July 5 ind./l	July 5 %	July 8 ind./l	July 8 %	July 9 ind./l	July 9 %
Rhizosolenia eriensis H. L. Smith								
Stephanodiscus tenuis Hust.	330		900		240		90	
Synedra acus Kütz.	90		90		60			
S. ulna (Nitzsch.)Ehr.			6					
Bacillariophyceae total	2460	26,3	2460	38,3	942	6,0	402	23,8
Actinastrum hantzschii v. *gracile* Roll			90		30			
Ankistrodesmus acicularis (A. Br.) Korsch.	60				60		30	
A. falcatus (Corda)Ralfs	2280		2100		1380		660	
A. falcatus v. *setiforme* Nyg.	60		30		30		30	
A. longissimus f. *septatum* Chod.	6		6					
Chodatella quadriseta Lemm.					60			
Coelastrum microporum Naeg.			6				30	
Crucigenia apiculata Schmidle	6		6					
Cr. tetrapedia (Kirch.)W. et G. S. West			60		30			
Dictyosphaerium pulchellum Wood	840		330		240		120	
Didymocystis planctonica Korsch.					30			
Elakatothrix lacistris Korsch.								
Hyaloraphidium contortum v. *tenuispinum* Korsch.					12000			
Kirschneriella arcuata G. M. Smith	270		150					
Micractinium pusillum Fr.	6		90		6			
Oocystis borgei Snow			30		30		30	
Pediastrum boryanum (Tupr.)Menegh.			6					
P. duplex Meyen								
Scenedesmus acuminatus (Lagerh.)Chod.	30		6		30		30	
Sc. brevispina v. *bicaudatus* Hortob.	30				60			
Sc. denticulatus v. *linealis* Hangs.								
Sc. ecornis (Ralfs)Chod.	30							
Sc. intermedius Chod.			30					
Sc. quadricauda (Trup.)Bréb.	60		60					
Selenastrum minutum (Naeg.)Collins	210		60					
Tetraedron minimum (A. Br.)Hangs.			30					
Tetrastrum glabrum (Roll)Ahl. et Tiff.	30		90		150			
Chlorococcales spp.	840		300		300		120	
Carteria cordiformis (Carter)Dill	90							
Chlamydomonas globosa Snow	240							
Ch. reinhardii Dang.	690		60		120		60	
Closterium acutum Bréb.	6							
Volvox aureus Ehr.	6							
Chlorophyta total	5814	62,1	3540	55,3	14556	93,06	1110	65,8
Total number of algae	9354	100	6414	100	15642	100	1686	100
Planctomyces bekefii Gim.	2640		2103		120		90	

July 16		July 25		July 30		August 6		August 21		August 27		September 3	
ind./l	%	ind./l	%	ind./l	%	ind./l	%	ind./l	%	ind./l	%	ind./l	%
										30			
300		240		480		360		150		300		270	
										30			
		6		12		30							
60		30						90		60		30	
3600	16,7	2202	28,9	1392	32,3	1290	10,8	1260	9,9	570	3,6	696	18,7
								330		930			
210		30		120		540		810		150		30	
9600		1980		600		2290		810		810		540	
		240		60		150		210		390		30	
		30		30				30		60			
60								90		540		30	
180						60		30		300			
450		30		120		450		180		60		6	
30		120						90		180		180	
30		120				90		180		180		120	
390		120		60		480		900		1890		120	
330		60		120		750		120		180		60	
120						30							
				30						90			
360				120		180		1800		210		60	
				30		30				60			
		30		30		30		30					
30						30		60					
150		120		60		120		180		90			
30				60		150		60					
		6											
210		60		60		240		150		180			
180		30				120		270		150		90	
120						90		90		30		90	
120				120		90		180		30			
30		120		30		150		90					
390		540		120		870		690		1800		330	
		30								6		30	
60		60		60		60		180		240			
										60			
13140	60,7	3636	47,8	1860	43,1	7020	58,5	7470	58,7	8436	53,7	1536	41,3
21612	100	7608	100	4313	100	12000	100	12690	100	15732	100	3720	100
900		90		30		330		690		1860		4800	

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RESULTS OF THE ZOOPLANKTON INVESTIGATION OF THE BAY AT ABÁDSZALÓK

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Abstract

The results of the qualitative and quantitative investigations of the Zooflagellata, Rotatoria, and Crustacea fauna of the bay at Abádszalók are giving a picture of the formation of the zooplankton to be expected after filling up the future reservoir.

Introduction

In the framework of studying the hydroecological problems of the future Kisköre Reservoir (in Middle Hungary), apart from investigating the supplying Tisza river (ÁDÁMOSI, et al. 1974, B. TÓTH 1975, VÉGVÁRI, 1975*a*) and an experimental area (BANCSI 1975, HAMAR 1975), in 1974 we had an opportunity to perform some investigations in the bay at Abádszalók, constituing about a tenth part of the future reservoir (12 sq.km surface), under conditions approaching the natural state of the area that will only be formed permanently after being filled up. The Tisza inundated the flood-plain on two occasions, owing to its inordinate water-movement (VÉGVÁRI 1975*b*). Thus we were enabled to carry out the investigations both under summer (July 3rd—August 27th) and autumn-winter (October 23rd—December 17th) weather conditions. During the work we have carried on physical and hydrochemical (VÉGVÁRI 1975*c*), bacteriological and algological investigations (HAMAR 1975), as well as Zooflagellata, Rotatoria, and Crustacea studies.

Material and method

The elaboration of the Zooflagellata fauna was performed by our colleague, J. HAMAR from living samples and by using ladled samples fixed with Lugol's solution, according to Utermöhl's technique. I wish to record my gratitude for his kind permission to publish his data, because in that way I could make my report on the zooplankton of the area investigated comprehending a much wider domain.

For investigating the Rotatoria and Crustacea plankton, we have used samples filtered through a plankton net made of a silk mesh tissue of 25 I/A quality. In case of all the samples, we have examined the complete material.

Zooflagellata fauna

In the course of the investigation, during the summer period, we could identify seven Zooflagellata species:

Bicoeca cylindrica (LACKEY) BOURR.
B. lacustris J. CLARK
B. planctonica KISS.
Bicoeca sp. (nova?)
Collodyction tricilliatum CARTER
Stelexomonas dichotoma LACKEY
Monosiga ovata KENT

In the autumn period, we couldn't find any species at all, belonging to this group.

Species Bicoeca were found in the Tisza dammed (BANCSI 1975), in the experimental area filled up with Tisza water (BANCSI 1975), and in the main canals belonging to the reservoir. *Stelexomonas dichotoma* turns up in the Tisza. In the Bay, the Zooflagellata count has changed between 6 to 60 thousand ind./litre. In the investigating period, we did not find any organisms indicating pollution.

Rotatoria fauna

In the course of investigating the Rotatoria fauna of the bay at Abádszalók we found 53 taxons. The enumeration of species is contained in the following table:

It appears from the enumeration that during the comparatively short investigating period a considerable number of Rotatoria taxons could be found. In the summer period, the species number was nearly a double as compared with those observed in the autumn-winter period. A majority of the turned-up species are to be found in the Tisza (MEGYERI 1955, 1957, 1970, BANCSI 1975) and its backwaters (MEGYERI 1961), as well as in the borrowing area (VARGA 1928, 1930).

Taxon	summer period	autumn-winter period
Anuraeopsis fissa (GOSSE)	+	–
Asplanchna priodonta GOSSE	+	+
Asplanchna siboldi LEIDIG	+	–
Brachionus angularis GOSSE	+	+
Br. calyciflorus var. *dorcas* (GOSSE)	+	+
Br. calyciflorus f. *amphiceros* (EHRB.)	+	–
Br. calyciflorus var. *dorcas* f. *spinosa* (WIERZEJSKI)	+	–
Br. falcatus ZACHARIAS	+	–
Br. quadridentatus typica HERMANN	+	–
Br. quadridentatus var. *brevispinus* (EHRB.)	+	–
Br. quadridentatus var. *cluniorbicularis* SKOR.	+	–
Br. quadridentatus var. *rhenanus* (LAUTERBORN)	+	–
Colurella adriatica EHRB.	+	–
Conochiloides dossuarius (HUDSON)	+	–
Conochilus unicornis ROUSSELET	+	–
Euchlanis dilatata EHRB.	+	+
Dicranophorus epicharis HARRING-MYERS	+	–
Filinia longiseta (EHRB.)	+	+
Kellicottia longispina (KELLICOTT)	–	+
Keratella cochlearis cochlearis (GOSSE)	+	+
K. cochlearis var. *macracantha* LAUTERBORN	+	–
K. cochlearis f. *micracantha* LAUTERBORN	+	+

Taxon	summer	autumn-winter period
K. cochlearis var. *tecta* (GOSSE)	+	–
K. cochlearis var. *irregularis* f. *angulifera* LAUTERBORN	+	–
K. testudo (EHRB.)	–	+
K. valga (EHRB.)	+	–
K. quadrata (O. F. MÜLLER)	+	+
Lecane bulla (GOSSE)	+	–
L. closterocerca (SCHMADRA)	+	–
L. hamata (STOKES)	+	–
L. lunaris (EHRB).	+	+
Lepadella rhomboides (GOSSE)	+	+
Lopohocharis salpina (EHRB.)	–	+
Pedalia mira (HUDSON)	+	–
Platyias patulus (O. F. MÜLLER)	+	–
Pl. quadricornis var. *pentagona* WULFERT	–	+
Polyarthra dolychoptera IDELSON	–	+
P. euriptera WIERZEJSKI	+	–
P. major BURCKHARDT	+	–
P. remata SKORIKOV	+	–
P. vulgaris CARLIN	+	+
Pompholyx sulcata HUDSON	+	–
Rotaria rotatoria (PALLAS)	–	+
Synchaeta grandis ZACHARIAS	+	–
S. oblonga EHRB.	+	+
S. pectinata EHRB.	–	+
Testudinella mucronata (GOSSE)	+	+
T. patina (HERMANN)	–	+
Trichocerca bicristata (GOSSE)	–	+
Tr. birostris (MINKIVICZ)	+	+
Tr. capucina (WIERZEJSKI u. ZACHARIAS)	+	–
Tr. pusilla (JENNINGS)	+	–
Trichotria pocillum (O. F. MÜLLER)	–	+

After surveying the quantitative data of the summer period, it was striking that, corresponding to the season besides the species *Anuraeopsis fissa, Brachionus calyciflorus* f. *amphiceros, Filinia longiseta, Keratella cochlearis,* the species *Polyarthra remata* and *Synchaeta oblonga* preferring rather cool waters, were members of the plankton, occurring in a considerable number.

In the days following the flood, the number of the planctonical Rotatoria surpassed 90 thousan ind./100 l. Their quality then decreased more and more, reduced in a month (August 6th) to a minimum characterized by a value not more than 220 ind./100 l. Of that period, the aquatic macrovegetation breaking forth and the change in the production of the planktonical algae, *i. e.*, a considerable fall in the quantity of the algae serving for food to the Rotatoria species was characteristic. The flood passing, the macrovegetation perishing and being mineralized, rendered possible the development of recent alga (and jointly Rotatoria) maxima (on August 21st: 34 thousand ind./100 l; on August 27th: 94 thousand ind./100 l). The species combinations of the initial (July 3rd) and final periods (August 27th) were very similar to each other. The phytophilous species found in large number on August 27th (*Lecane* spp., *Lepadella* spp.) and *Conochiloides dossuarius* are worth mentioning. The latter one occurred in the initial period but occasionally, in a small number; at the end of August, however, it was one of the dominant species of the Rotatoria plankton.

Taxon	Summer	aétumn-winter Period
Cladocera		
Alona rectangula SARS	+	+
Bosmina longirostris (O. F. MÜLLER)	+	+
Ceriodaphnia megops SARS	+	−
Ceriodaphnia reticulata (JURINE)	+	−
Chydorus sphaericus (O. F. MÜLLER)	+	+
Daphnia cucullata SARS	+	−
Daphnia hyalina var. *lacustris* SARS	+	+
Diaphanosoma brachiurum (LIÉVIN)	+	−
Leptodora kindtii (FOCKE)	+	−
Moina rectirostris (LEYDIG)	+	−
Pleuroxus aduncus (JURINE)	+	+
Scapholeberis kingi SARS	+	−
Scapholeberis mucronata (O. F. MÜLLER)	+	−
Simocephalus vetulus (O. F. MÜLLER)	+	−
Calanoida		
Eudiaptomus gracilis G. O. SARS	+	+
Cyclopoida		
Acanthocyclops vernalis FISCHER	+	+
Cyclops strenuus FISCHER	+	−
Megacyclops viridis JURINE	+	−
Mesocyclops leuckartii CLAUS	+	−
Thermocyclops oithonoides G. O. SARS	+	−

In the autumn-winter period (October 23rd to December 17th) the dominant species of the plankton of Rotatoria were the psychrophilous *Polyarthra dolychoptera, Synchaeta oblonga, Synchaeta pectinata* and the euriek *Keratella cochlearis* preferring the rather cold waters. The tendency of the change in individual density was similar to that observed in the summer period, although the individual number of the occurring species was considerably lower than in Summer. The quick decrease in the comparatively high values (3.700 ind./100 l) of the initial period (October 23rd to October 29th) was followed by a thin Rotatoria population (140—600 ind./100 l) for almost one month. Before the flood passing (December 10th to 17th), the individual density rose rocketing to 18—20 thousand ind./100 l.

Crustacea fauna

In the course of the investigation, 14 Cladocera, 1 Calanoida, and 5 Cyclopoida taxons were identified (Table 2).

Of the plankton of Crustacea, apart from the richness in species, the considerable plankton density was characteristic. The individual number of two from the 14 Cladocera species, namely *Bosmina longirostris* and *Moina rectirostris,* surpassed 5 thousand ind./100 l on several occasions. The individual density of the Cyclopoida species increased and later decreased, simultaneously with the multiplication of the species Rotatoria and Cladocera. In the period of the summer flood passing, there couldn't be found any well-developed individuals.

In the autumn-winter period, the plankton of Crustacea in the bay at Abádszalók was formed by not more than 5 Cladocera, 1 Calanoida, and 1 Cyclopoida. Their individual density, too, was considerably smaller than in Summer.

After comparing the zooplankton data of the Tisza as the supplying water-course of the future reservoir, and those of the bay at Abádszalók as a part of the reservoir that is to be considered as characteristic (Fig. 1), we may establish that in the reservoir

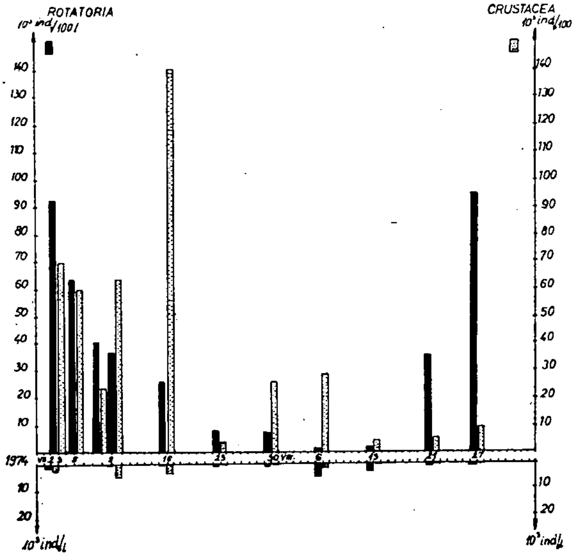

Fig. 1. The quantitative relation between the planktons of Rotatoria and Crustacea in the bay at Abádszalók and the Tisza

in the period after being filled up, there can develop a zooplankton stand that is considerably richer in species than that in the Tisza, having a 20 to 100 times greater individual density than the stand in the Tisza. The characteristic river-water plankton of the Tisza will be followed in the reservoir, in a comparatively short time, by the development of a backwater plankton, promoted also by spreading and multiplying of the fauna of the water-spaces of the flood-plains (backwaters, borrow areas).

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PRELIMINARY INVESTIGATIONS OF THE EXPERIMENTAL AREA IN THE INTEREST OF PROTECTING THE WATER QUALITY OF THE FUTURE KISKÖRE RESERVOIR

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Abstract

The preliminary investigations carried out by us in the experimental area designated in the vicinity of Abádszalók have served partly for evaluating the quantity of organic matter and vegetable food there, partly for proving the right selection of the sampling points designated for the regular hydrochemical and biological investigations.

Introduction

It is an important task to determine the quantity of organic matter and vegetable food content (nitrogen, phosphorus), remaining in the area of a reservoir, before filling up the reservoir, as in case of knowing these results the load of organic matter and vegetable food on the reservoir can be evaluated in advance, taking into consideration the time of decomposition, as well.

Our preliminary investigations have prepared the surveyings of this character to be performed in the area of the Kisköre Reservoir. We have determined the organic matter, nitrogen and phosphorus content remaining in the experimental area, endeavouring to clear up the methodological questions that considerably facilitate the serial investigations later.

Material and method

The area of investigations is lying on the territory bordered by the old Tisza dike and the new dam north-north-west of Abádszalók. Its length is 2 km, its breadth changes between 200 and 400 m. Its surface is 404.000 sq.m, stretching out in the direction West-Southwest-East-Northeast (Fig. 1).

Filling up of the experimental reservoir took place in April 1974. The mass of water stored was 850.000 cc.m.

Along the dam lying on the side to Abádszalók, in a 50 to 100 m wide strip, a shelter-belt extends, formed mostly by willows variegated with ash-trees, trembling and white poplars. A part of the willow plantation was clear-felled in the winter before filling it up.

In the experimental area the remains of an old dead arm and an oozing canal are running. Before filling up, there was 1 to 1.5 m deep water in the canal, without reed-grass and uliginal vegetation. Along the dam-side of the backwater, in a 5 to 10 m wide strip, an ash-wood extends. The bed is silted up strongly. *Uticularia vulgaris*, *Iris pseudacorus* and various *Carex* species were growing in large numbers.

The N—NE-end of the experimental-reservoir is, forming, because of the bridge that crosses the oozing canal, a separate unit (Fig. 1) where before filling it up there was but some soft-stalked vegetation consisting of a few willow-bushes and uliginal weeds.

The representing sites, suitable for, taking soil samples, were demarkated after a thorough surveying of the area.

Soil samples were taken from four sites of the experimental area and are to be characterized by the following plants:

Soil sample 1: It is originating from a little variegated area with a mostly soft-stalked vegetation of small stature. Its characteristic plants are: *Potentilla anserina* L., *Ranunculus repens* L., *Carex distans* L., *Glechoma hederacea* L., *Lotus corniculatus* L., *Euphorbia salicifolia* HOST.

Soil sample 2: It was taken from an area with a vegetable stand rich in species, its plants being: *Trifolium repens* L., *Agropyron repens* (L.,) BEAUB., *Cirsium arvense* (L.) SCOP., *Symphytum officinale* L., *Euphorbia salicifolia* HOST., *Carec distans* L., *Festuca pratensis* HUDS., *Rubus caesius* L., *Tussilago farfara* L., *Chrysanthemum vulgare* (L.) BRENK, *Matricaria inodora* L.

Soil sample 3: It is originating from a site that has a thinner-scattered vegetable stand than the former areas. Its plants are: *Althaea officinalis* L., *Potentilla reptans* L., *Cirsium arvense* (L.) SCOP., *Rorippa silvestris* (L.) BESS, *Rubus caesius* L., *Salix fragilis* L., *Amorpha fruticosa* L.

Soil sample 4: It was taken from a deeper-lying, marshy area, containing only *Chrysanthemum vulgare* L.

There is no uniform methodology concerning the methods of soil investigations to be performed from the point of view of water quality; therefore we felt it necessary to drescribe the method applied by us, so that the results may be compared later.

Sampling: By means of a shovel-shaped spade, the vegetation was removed together with a 25×25×10 cm earth ball.

Preparation: In the laboratory, the sample is cut in 15×15×10 cm, then the living green vegetation *(C-fraction)* and the dry vegetable remains *(B-fraction)* are separated from the surface obtained. Following that, the 15×15×10 cm earth piece is cut in 15×15×2 cm *(A-fraction)* and put on a tile. The samples are dried at 105 °C in an exsiccator till getting weight-balance. After being cooled down, they are weighed, and in that way we get the dry weight of A-, B-, and Cfractions. For a further preparation the samples are ground in a soil-milling machine, in order to be homogenized completely.

The determination of the total nitrogen and phosphorus content is methodically elaborated (FELFÖLDY 1974). We achieve well-measurable extinction values (0.5 to 0.8) if we choose the mass to be weighed as a function of the total organic matter. The more organic matter is contained in the given fraction of the sample, the less of that is to be recorded.

The determination of the oxygen requirement of the sample measured with acid potassium permanganate was carried out with the method applied in hydroanalytics (FELFÖLDY 1974). The oxygen requirement of the 15×15×2 cm sample is given by the sum of fraction values.

From the values of the C. O. D. measured with potassium permanganate, the organic carbon can be calculated on the basis of the following formula (FELFÖLDY 1974).

Organic C mg/sample = 0.1898 "C.O.D.Mn" (sample = 15×15×2 cm soil sample)

For designating the sampling points of the area filled up with Tisza-water, we have taken water samples in six profiles, from four sampling points each (Fig. 1).

Evaluation of results

On the basis of the data obtained in the course of the laboratory investigations, the quantity and oxygen demand of the matters, that exert a considerable influence upon water quality after remaining in the experimental reservoir, could be evaluated.

The total organic matter was 1510 tons, of which 1114 tons were found in the 2 cm surface layer of the soil, and 406 tons in the vegetation contained. While from the 406 ton organic matters found in the vegetation 262 tons were at the shrub and tree-levels, hardly more than one third of them, 144 tons were found at the grass-level.

The total nitrogen quantity remaining in proved to be 27 tons, the total phosphorus quantity 8 tons.

On the basis of the values of C. O. D., measured with acid potassium permanganate, 4.000-ton oxygen is necessary to oxidize the organic matter in the 2 cm upper layer of the soil and at grass-level. That is 600 times as much as the oxygen demand of the organic matter that got in with feed-water till filling up the reservoir completely.

From the results obtained in the course of the elaboration, the data of *soil sample 2* are given here as an illustration [g (sample) 15×15×2 cm].

fraction A B C Total 2 cm layer of the soil dry vegetation green vegetation

Component				Total
Total weight (dry)	447.0000	20.7889	19.4200	497.20
Organic matter	36.3174	11.1451	17.8712	64.3337
Inorganic matter	410.6826	9.6438	1.5488	421.8752
Total nitrogen	0.9311	0.2430	0.3383	1.5124
Total phosphorus	0.3759	0.0209	0.0489	0.4457
C.O.D.Mn.	86.88	68.48	102.70	258.06

On the basis of soil investigations we could ascertain that the organic matter and vegetable food contained only in the soil and grass-level of the land-ecosystem under inundation is representing such a considerable quantity that in our case it would accumulate in the experimental area as many as 2.000 years, in spite of the water supply providing for the replacement of the loss of oozing and evaporation.

Another important aim of our preliminary investigations is to supervise the selection of the previously designated sampling points that became necessary to survey the water conditions of the experimental area reliably.

The investigations have comprised the determination of dissolved oxygen, free carbon dioxide, the C. O. D. measured with potassium permanganate, dissolved orthophosphate, pH, conductivity, sodium, potassium, "a", "b", and total chlorophyll.

At determining the sampling points, besides the results of profile investigations, we took into consideration the bottom-formation of the experimental area, the different vegetation of the sites lying deeper or higher, whether the post-inundation water-surface is unsheltered from the wind or not, as well as the different degrees of being shaded, the comparatively isolated state of the single sites, the local differences in the degrees of water exchange, as well. On the basis of these took place the designation of the five sampling points. (Fig. 1).

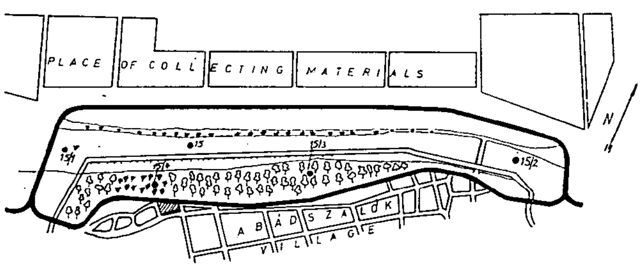

Fig. 1. Plot of the experimental area with the sampling points

Sampling point 15: It was designated in the open-water part of the old backwater, sheltered from the wind moderately. Water depth changed between 3.00 and 3.30 m.

Sampling point 15/1: It was in the western part of the reservoir. Before the inundation, vegetation and surface soil were completely missing. Here ran the pipe work providing for the water supply. Water depth was 2.00 to 2.3 m.

Sampling point 15/2: It was designated in the easter part of the experimental area, in the middle of the part lying between the bridge that crossed the oozing canal and the dams. Before inundation, there were weed-associations in the area. Water depth has changed between 1.80 and 2.10 m.

Sampling point 15/3: It was designated in the strongly shaded protective forest of dense foliage, bordering the reservoir from Abádszalók. The underwood was formed by ash and willow-bushes. Water depth fluctuated between 1.10 and 1.40 m.

Sampling point 15/4: It was designated in the wood cut down. In the early summer period it was but a little shaded, later on however it bacame strongly shaded owing to the dense canopy of the willows coming into leaf. Before inundation, the bottom was covered by a thick leaf-litter layer. Water depth was 1.40 to 1.70 m.

For studying the conditions of water quality in the experimental area (hydrochemical and biological investigation), samples were taken from sampling point 15 weekly, from sampling points 15/, 15/2, 15/3 and 15/4 fortnightly (B. Tóth 1975, Hamar 1975, Bancsi 1975).

In the course of our preliminary investigations carried out in the experimental area at Abádszalók, we evaluated the quantity of vegetable food remaining in the inundated area, as well as we designated, on the basis of chemical and biological investigations, the representative sites for sampling, promoting in this way that we can give correct answers concerning the water quality of the area inundated, with our hydrochemical and biological investigations to be performed in the experimental area in 1974.

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HYDROCHEMICAL CONDITIONS OF AN EXPERIMENTAL AREA IN THE REGION OF THE KISKÖRE RIVER BARRAGE

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(Received 30 June, 1975)

Abstract

In the course of the systematic chemical investigations carried out in the experimental area we followed with attention the components that are, in respect of their quantitative and qualitative conditions, in connection with the water biocoenosis, and the direction and degree of their change give us information on the displacement in water quality that may be favourable or unfavourable from human point of view.

Introduction

For the defence of water quality in the Kisköre Reservoir, an area of 4 sq.km. extension, covered with a rich vegetation, was inundated with Tisza water. We carried out in that experimental area chemical and biological investigations in 1974 whose aim was to examine the factors having, in all likelihood, an influence on the water quality of the Kisköre Reservoir. Our samples were taken from regions of different plant covering (woods and open water), and we studied how necessary it was to remove woods and brush-woods from the region of the Reservoir.

Material and method

We carried out our investigations in the experimental area from May 28th till December 17th. 1975. Our samples originated from five sampling points (15; 15/1; 15/2; 15/3; 15/4), with a fortnightly recurrence. For the chemical analyses 5 l ladled samples were taken. For examining the dissolved oxygen and free carbon dioxide, special samplers were used.

The chemical investigations were performed on the basis of the Standardized Methods of COMECON for Water Examination, published by VITUKI (1970), and of Felföldy's lecture notes, titled: 1. Biological water qualification (1974).

Results of the investigations

In the course of the hydrochemical investigations we followed with attention the components that, in respect of their quantitative and qualitative conditions, are in connection with the water biocoenosis, the direction and degree of their changes giving us information on the changes in water quality of favourable or unfavourable degree from human point of view.

In my paper I don't want to publish a full series of data, I should only like to draw the attention to the tendency of changes.

The water of the experimental area is slightly basic, pH changed between 7.1 and 8.3. The pH values are higher permanently in the months August and September. Its seasonal change agrees well with the tendency of change in the total algal number (HAMAR 1975).

On the basis of conductivity and the data of the total dissolved material, the water of the experimental-reservoir changed between 313 and 516.10^{-6} $ohm.cm^{-1}$ during the year. The conductivity values arose, except for a lesser dilution contemporaneously with the rainy weather in October, what can be brought into connection partly with the dissolution of the mineral substances of the soil, partly with evaporation.

The dissolved oxygen and free carbon dioxide play a considerable part in the assimilation and dissimilation of the autotrophic and heterotrophic water organisms. In the course of studying the oxygen and carbon dioxide circulation we can get a picture of the biological processes taking place in the water areas.

The organic-matter loading of the experimental area is shown well by the oxygen and carbon-dioxide results of our annual investigations series (Fig. 1).

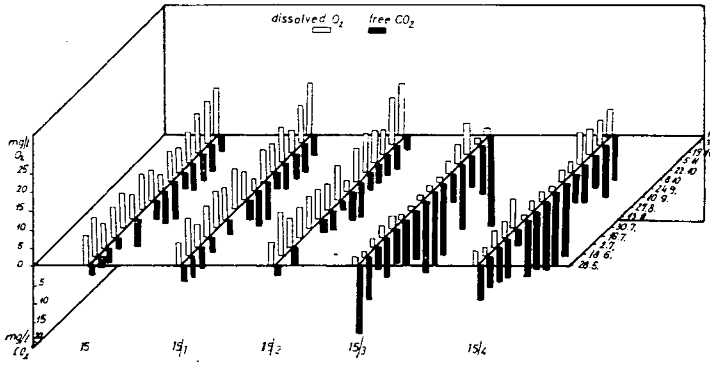

Fig. 1. Formation of the dissolved oxygen and free carbon dioxide content of the experimental area in 1974

The amount of dissolved oxygen varied in the areas of open water and wood in an equally broad interval (at sampling points 15; 15/1; 15/2 between 2.9 and 14.1 mg/l, at sampling points 15/3; 15/4 between 1.5 and 12.0 mg/l) but the values measured in open water were always higher than those measured in wooded areas. In the corresponding periods the dissolved oxygen content of the water in wooded areas is often 5—7 mg/l less than that of an open water.

The different organic-matter load on the various water areas is shown by the oxygen saturation expressed in percentage even more conspicuously. The oxygen saturation was in open-water areas generally between 70—90 per cent, in the water area of a deciduous wood, let alone an exception, it was between 50—60 per cent. In the wooded areas, in the region close to the bottom, we have observed aerobic conditions, as well, from time to time.

The intensive breakdown of the organic matter is well reflected also by the high free carbon-dioxide content of water in the experimental area.

The quantity of free carbon dioxide achieved 10—15 mg/l at sampling points 15/3 and 15/4 in the summer period, and even 20 mg/l in Autumn and Winter. At the open-water sampling points 15; 15/1; 15/2 we have got a ilttle lower values; the quantity of free carbon dioxide was 3—6 mg/l in Summer, nearly 10 mg/l at the end of September and in early October, and in the winter period it was 5—7 mg/l. In open water (15), in the summer period, we could not demonstrate any free carbon dioxide, these periods coincided with the time of phytoplankton maxima (HAMAR 1975). The C. O. D. by the water area and measured with potassium permanganate and potassium dichromate changed considerably during the experimental period. The values of the potassium dichromatic C. O. D. are indicating well the formation of the organic-matter content in the area.

In spite of the values changing strongly after being inundated, the data of the physiognomically different areas became separated well from one another. In August we observed a rising tendency at every sampling point (at sampling point 15/3 measuring 48 mg/l), followed by a general decrease; and then followed a regional equalization in the time of the october rainfall (20—30 mg/l values). In December, however, the open-water and wooded areas considerably separated: the values measured at sampling points 15; 15/1; 15/2 were between 20—26 mg/l, while those measured at sampling points 15/3—15/4 were between 48—51 mg/l.

We have systematically investigated the seasonal dynamics of anions and kations, determining the chemical character of water fundamentally.

From among the anions, only the hydrogen carbonate occurred in a high enough quantity for determining the water type (Fig. 2). Its amount rose about 100 mg/l from the spring inundation till December. We measured 160 mg/l in June, 278 mg/l in December. In the various water areas, too, similar conditions predominated.

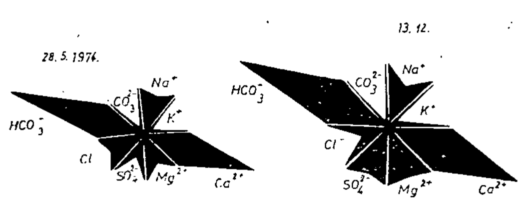

Fig. 2. Initial and end-state of ion-concentration in the experimental area in 1974

The carbonate ion could be demonstrated from the water of the experimental area only on a few occassions and in a very small amount.

The chloride content was comparatively permanent in the experimental period, its mass fluctuated at about 25 mg/l.

In the course of our investigations, the quantity of sulphate rose to 3 to 4 times as much as the initial value was, its seasonal formation showed a peculiar connection with the water temperature, oxygen saturation, and the total iron content.

The change in the sulphate content of the waters is fundamentally determined by the processes taking place in the sediment and the water layer above it.

From the vegetable remains of cellulose content of the sediment hydrogen sulphide develops in the course of the activity of the sulphate-reducing bacteria. Is dissolved iron present in the water, then the hydrogen sulphide is transformed into ferrous sulphide and settles (1). At the sediment-surface becoming earobic the following process takes place:

$$FeS + 2\,O_2 \rightarrow FeSO_4 \qquad (2)$$

FeS hydrolyses with water:

$$FeSO_4+2\,H_2O \rightarrow Fe(OH)_2+H_2SO_4 \tag{3}$$

Sulphuric acid reacting with the FeS not yet oxidized releases H_2S:

$$FeS+H_2SO_4 = FeSO_4+H_2S \tag{4}$$

H_2S can get into reaction with the oxygen in water in the course of which elemental sulphure precipitates:

$$2\,H_2S+O_2 \rightarrow 2\,H_2O+2\,S \tag{5}$$

The water becomes opalescent by the precipitating sulphur, then it thinks to the bottom where it may be transformed into sulphuric acid as a result of a slow oxidation. (VÁMOS 1959, VÁMOS *et al.* 1963, 1971, KÖVES—VÁMOS 1959).

The data measured at the sampling point 15/3 of our experimental area agree well with the process outlined above. The decrease in iron content was always observed when the dissolved oxygen content of water was very low in the region near to the surface, and the sediment was very probably anaerobic. The considerable decrease in the quantity of the dissolved iron in July and August can be brought into connection with the formation of ferrous sulphide (1). The improvement of the oxygen conditions is favourable to the dissoluble ferrous sulphate, involving an increase in the iron and sulphate content of water (2). Phenomena 2, 3, and 4 could be observed on two occassions (July 30th, November 19th). Then the water became opalescent owing to the precipitated elemental sulphur granules.

The processes outlined above are drawing the attention to the wooded areas.

In the course of the investigation, the quantity of cations, apart from a few exceptions, increased more and more, probably as a result of the concentration taking place during the evaporation. From the inundation till December, sodium increased 5—7 mg/l, potassium 1.5—4 mg/l, calcium 20—24 mg/l, the change in magnesium content was not considerable.

The water of the experimental area was, let alone a single case, of type calcium-hydrocarbonate.

The Hungarian and foreign literatures attribute the cause of eutrophication to the increase in the nitrogen and phosphorus amount getting into the water. The multipurpose utilization of the future Kisköre Reservoir would be touched on a sore spot by a discontinuous eutrophication after being inundated. Starting from that, one of the most important subject-matters of our investigations was the nitrogen-phosphorus economy.

On the basis of the investigations concerning the nitrogen circulation it may be established that inorganic nitrogen was always present in the water area although some of the forms were from time to time missing. The quantity of the nitrogen of organic bond was the largest at the end of May and August, and in the middle of December, in the meantime we observed larger or smaller decrease.

In the summer period, after the spring phyto- and zooplankton maxima, we observed a decrease in organic and inorganic nitrogen, as a result of the strong expansion of the water macrovegetation. The nitrogen accumulation of the wooded areas was two to three times as much as that observed in open water.

In the course of studying the phosphorus forms, we have met with an obvious difference between the model-accumulating open-water area (15; 15/1; 15/2) and the wooded area (15/3; 15/4) (Fig. 3).

The seasonal formation of the single phosphorus forms was of similar course but their quantity in the wooded area was, as a rule, considerably larger than in open water.

According to literary data (ORR, I, *R*. 1968, SAWYER, 1966, FELFÖLDY—B. TÓTH 1970), the intensive production of waters is already facilitated by more than 30 mg/cc.m total phosphorus. In the experimental area we have often measured even 5 to 20 times as much as that value but no mass algal production has developed for a longer time. The cause of that cannot be discovered unequivocally by means of

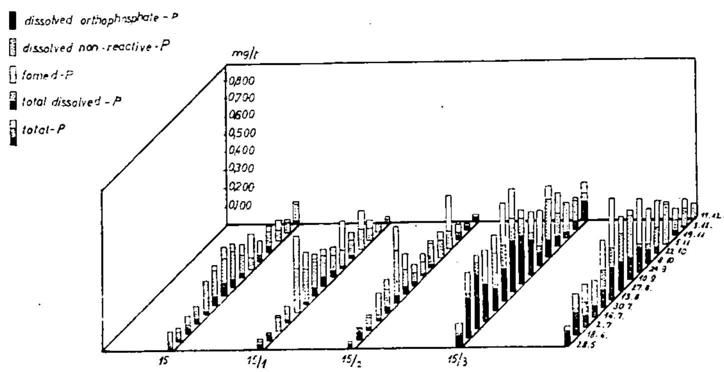

Fig. 3. Formation of the phosphorus forms in the experimental area in 1974

the investigations but it appears from the total data that, apart from the expansion of macrovegetation and the deprival of nutritive material by it, some kind of inhibition may have taken part, as well, because but a minimum part of the available nutritive material was consumed.

The results obtained in the course of investigating the physiognomically different water areas (with woods and open water) unequivocally draw our attention to that the presence of the shrubs and woods (the mass of vegetable organic matter) left in the Reservoir exert an unfavourable effect on the formation of water quality in the experimental area.

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INVESTIGATION OF BACTERIO- AND PHYTOPLANKTON IN THE EXPERIMENTAL AREA OF ABÁDSZALÓK AT THE KISKÖRE RIVER BARRAGE

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Abstract

The paper is giving the bacteriological and algological comparison of the open-water and wood-covered parts of an inundated experimental area, emphasizing that the woods left in the Reservoir are resulting in an unfavourable water quality.

Introduction

In the area of the future Kisköre Reservoir some wood and shrub stands are to be found. For proving the necessity of removing these, experiments started in a 4 sq. km experimental area where one half of the water surface is open water, the other half is a wooded region. By comparing these, the effect of wooded regions on the chemical and biological composition of the water could be followed (B. TÓTH 1975, BANCSI 1975, B. TÓTH—VÉGVÁRI 1975, B. TÓTH—HAMAR 1975, HAMAR—BANCSI 1975).

Method

The investigation of the total bacterium number was carried out with the membrane-filter method (FELFÖLDY 1974). The determination of the colonies of bigger bacteria and that of the algal count was carried out with Utermöhl's technique. The chlorophyll content was determined with methanol solution (FELFÖLDY 1974). During the period of investigation (May 28—December 17, 1974) a number of samples were taken from five standing sampling points, from the vicinity of surface, with a fortnightly frequency. In the course of discussing the results, owing to the similar character of the single sampling points, we are giving only the comparison of open-water and wood-covered areas. Bacterioplankton was investigated by I. BANCSI, the results of the chlorophyll content were placed at my disposal by MÁRIA B. TÓTH. I wish to express them my thanks in this way for their generous aid.

Results

Al the bacterial number data, let alone the initial period after damming, gave curves of similar courses at every sampling point. At the first investigation (May 28) in the open-water areas the total bacterial number was 5—6 million ind./ml, in the wooded areas 11—13 million ind./ml. In the course of Summer we observed some increase (12—16 million ind./ml) and the values of the open-water areas were generally higher. The late summer — autumn minima (10—16 million ind./ml) were followed by autumn-winter maxima. The December maxima were high at every point (50—110 million ind./ml). In the period between May and October, the bacillus and vibrio forms were more frequent, in Winter, however, the bacterioplankton was formed almost exclusively by tiny cocci. Comparing the results to the total bacterium number of the Tisza, the bacterium count of the experimental area is much lower than that of the flooding Tisza and is similar to the values of the summer bacterioplankton of the river dammed up at Kisköre (HAMAR 1975*a*).

In the wooded area, the surface of water was, on more occasions, covered with a foamy bacterial membrane. That black oil-like membrane consisted of carbonized vegetable remains and of the mass of bacilli- and cocciform bacteria swarming on them. The vegetable remains, disintegrating on the bottom—generating often hydrogen-sulphide and causing lack in oxygen — are carried on the surface by gasbubbles generated among them.

While *Planctomyces bekefii* GIM. (HAMAR 1975*a*), indicating eutrophic water, several times occurred in open-water areas in the vegetation period (maximum 5.4 million ind./l), it was present in the wooded area, much richer in food, only in the first period after damming (6 million ind./l), later it was missing. The iron bacterium Leptothrix echinata Beger occurred only in open water, in a quantity of 6—60 thousand colonies/l.

It was shown by the bacteriological investigations that the development of the bacterioplankton in the wooded area was checked and the intensive bacterial activity took mainly place on the surface of the sediment and of devitalized vegetable remains.

The experimental area got its water from the Tisza. It is therefore not accidental that the dominant species of its phytoplankton got into it from there. The distribution of alga taxons found in the experimental area are as follows:

Cyanophyta	11
Euglenophyta	19
Pyrrhophyta	10
Chrysophyceae	24
Bacillariophyceae	20
Xanthophyceae	1
Chlorophyta	67
Sum total:	152

In its qualitative composition it is similar to the phytoplankton of the dammed Tisza-reaches (HAMAR 1975*a*), although there occurred some rare species, too, that are originating from the dried dead arm and borrows lying in the experimental area (HAMAR 1975*b*).

In the middle of the Summer, the blue alga *Anabaena flos-aquae* KLEB. induced water colouration in the open water. In the shallow water of the wooded part the fist-sized jelly-like colonies of *Gloeotrichia natans* (HEDWIG) RABEN were found. *Aphanizomenon issatschenkoi* (USSAT.) PORSCH., living in large numbers in eutrophic water, was found here, as well, but without causing algal bloom (H. BARTHA 1974). From the Euglenophyta genus, *Phacus moniliatus* var. *suecicus* LEMM., living in marshy waters, is worth mentioning. From the Pyrrhophyta genus, the species *Cryptomonas* are very frequent (*Cryptomonas pusilla* BACH., *Cr. erosa* CHR., *Cr. marssonii* SKUJA, *Cr. ovata* EHR., *Cr. platyuris* SKUJA). Chilomonas acuta Schiller is qualified as a very rare species. From the family Chrysophyceae, Chrysococcus biporus Skuja occurred in almost every sample. In the winter period, the water of the wooded area was coloured by the colonies of *Synura uvella* EHR. We have found rare species, as well, as *Chrysidalis peritaphrena* SCHILLER, *Chrysochromulina parva* LACKEY, *Dinobryon elegantissimum* (KORSCH.) BOURR., *D. marchicum* LEMM., *D. suecicum* LEMM., *Heterochromas vulgaris* (CIEN.) PASCHER, *Heterolagynion oedogonii* PASCHER, *Pseudokephyrion pseudospirale* BOURR., *Kephyrion rubri-claustri* CONRAD, *K. rubri-claustri* var. *amphora* (LACKEY) CONRAD, *Mallomonas akrocomos* SKUJA, *Monas cylindrica* SKUJA (HAMAR 1975*b*). Diatoma are represented by planktonic species. *Cylindrothaeca gracilis* (BRÉB.) GRUN. occurred in a single case. From the plankton rich in green algae, the cosmopolitan algae were dominant (the members of the genera *Ankistrodesmus* and *Scenedesmus*). The colourless heterotrophic *Hyaloraphidium contortum* var. *tenuispinum* KORSCH. is remarkable; it often occurs in large numbers in plankton, and is originating from the polluted, eutrophic river Sajó, discharging into the Tisza above the river barrage.

From the late Summer, there appeared in plankton some species that are characteristic of the marsh waters and the alga-flora of borrows *Xantidium mirabile* (NORDST.) W. ET G. S. WEST, *Arthrodesmus convergens* EHR., *Cosmarium pygmeum* ARCH., *Gonatozygon monotaenum* DE BORY). From the rather rare species we mention the occurrence of *Scenedesmus aculeogranulatus* HORTOB., *Sc. coarctatus* HORTOB., *Tetraedron hastatum* var. *palatinum* LEMM., *Chlorogonium elongatum* DANG., *Chlorogonium minimum* PLAYF.

The richness in species of the water of a wooded area is much smaller than that of the open water.

The difference between both biotopes is reflected by the quantitative data accurately. The frequent species of the open-water area are to be found in the feed-water, as well, but their dominance is different. Characteristic dominant species are: *Ankistrodesmus falcatus* (CORDA) RALFS, *Cryptomonas pusilla* BACH., *Crysococcus biporus* SKUJA, *Stephanodiscus tenuis* HUST., that achieve even the million ind./l number. From the rare species, the individual numbers are as follows: *Chrysidalis peritaphrena* SCHILLER 120 thousand ind./l, *Dinobryon elegantissimum* (KORSCH.) BOURR. 210 thousand ind./l, *Carteria cordiformis* (CARTER) DILL 1.1 million ind./l, *Spermatozopsis exultans* KORSCH. 570 thousand ind./l maximum individual number (HAMAR 1975*b*).

The individual number of the heterotrophic green alga: *Hyaloraphidium contortum* var. *tenuispinum* KORSCH. is initially high, later on unimportant.

The dominant species of the phytoplankton of a water-inundated wooded area do not agree with those of the open water: *Oscillatoria* sp. (on May 28: 45 million ind./l), *Hyaloraphidium contortum* var. *tenuispinum* KORSCH. (on May 28: 45 million ind./l), *Trachaelomonas volvocina* EHR.

At comparing the results of the samples taken in every fortnight, it is remarkable that the development of the phytoplankton of the open-water part is normal, in the water of the wood-covered area, however, after the initial high total algal count, the development of phytoplankton is checked, even in spite of the available high food content (nitrogen, phosphorus) (B. TÓTH 1975). It was established by the investigations that in the water-covered wood a marshy vegetation and masses of filamentous algae had developed (B. TÓTH—HAMAR 1975).

The chlorophlyl content agrees in its tendency with the changes in total algal count, the correlation coefficient is, however, low (in case of open water: $r=0.29$). A precise measuring is disturbed by the broken plants in the water of the wooded area.

It is unequivocally proved by the experiences of the experimental area that after the inundation of the areas covered with wood and shrub there come about some conditions that do not satisfy the demands set up concerning the water quality of reservoirs.

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THE PART OF WATER VEGETATION IN EUTROPHICATION IN AN EXPERIMENTAL AREA AT THE KISKÖRE RIVER BARRAGE

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Abstract

The eutrophication of the areas inundated with water may quickly take place. In the area of the water-inundated flood-plain wood, the rise in the degree of trophity is indicated by a considerable multiplication of the filamentous algae developed on the decayed vegetable remains (biotectonic eutrophication), of the rooted (rhizobenthic eutrophication) and floating macrophytes (pleustonic eutrophication). Of the open-water area the high individual number of the members of phytoplankton (planktonic eutrophication) is characteristic.

Introduction

Beside the future Kisköre Reservoir an old flood-plain area, surrounded with a strong dam, has got under a lasting inundation. We have followed with attention the hydrobiological changes taking place in the area filled up with the water of the Tisza in various biotopes (BANCSI 1975, B. TÓTH 1975, B. TÓTH and VÉGVÁRI 1975, HAMAR 1975), paying a particular regard to the differences between the open water and the inundated woody area.

Material and method

On one side of the about 4 sq.km area (B. TÓTH and VÉGVÁRI 1975) a 50 to 100 m broad flood-plain wood is situated, consisting of *Salix fragilis* L. and sporadically containing *Populus alba* L. and *Populus tremula* L., as well. On the other side, a young stand of *Fraxinus pennsylvanica* MARSH. can be found, in a 5 to 10 m broad strip (Fig. 1).

In the present-day place of the open water an extinct dead arm was lying. The water of the wooded area became 1.5 m deep after being filled up, the maximum depth of the open water being 4 m. The experimental area was filled up with the water dammed by the Kisköre River Barrage, by means of pumps. The investigation lasted from Spring till Winter, in 1975.

Results

Following the filling, *Potentilla anserina* L. and *Euphorbia salicifolia* HOST. have remained in the shallow enough parts and there has begun also the diffusion of the water vegetation getting in with the filling water, and later on its local differentiation started, as well, owing to the different biotopes.

In the growing season, in the open water, a rare sub-association of *Nymphaetum albo-luteae* NOWINSKI *nymphaetosum* developed. The character species is *Nymphaea alba* L., the concomitant species are *Ceratophyllum demersum* L., and *Trapa natans* L. In the middle of the open water we have found some specimens of *Potamogeton lucens* L. (Fig. 1). The part of macrophytes is but a minimum in the open water, on the other hand, the phytoplankton has achieved a permanently high individual number (HAMAR 1975).

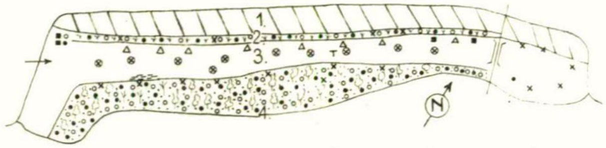

Fig. 1

Following the inundation, after the high phytoplankton individual number lasting in the wooded area but for a short time, the filamentous algae appearing on the subaquatic vegetable remains became dominant (*Spirogyra* spp., *Vaucheria* spp., *Cladophora* sp.). In the shallower parts, we have found the thalluses of the blue alga *Gloeotrichia natans* (HEDWIG) RABEN (Fig. 2) and those of *Hydrodictyon reticulatum* TURNER.

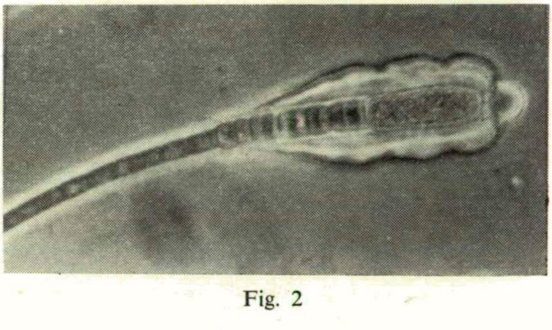

Fig. 2

The alga grasses regressed parallel with the wood coming into leaf, giving place to macrophytes. The macrophytes with drawing to the wood have formed a pure *Lemno-Utricularietum spirodeletosum* Soó sub-association. Character species are at the water surface: *Spirodela polyrrhiza* (L.) SCHLEID., and *Lemna minor* L. From among the submersed species, the dense stands of *Utricularia vulgaris* L., and *Lemna trisulca* L. are characteristic (Fig. 1). From among the concomitant species, *Ceratophyllum demersum* L., and *Polygonum amphibium* were present. In Autumn, parallel with the destruction of the water vegetation, bacterial and algal grasses appeared (HAMAR 1975) (Fig. 3).

In the thicket, too, lying along the other side of the open water, the *Lemno-Utricularietum spirodeletosum* Soó sub-association developed (Fig. 4). The character species are similar to the former one. As a concomitant species, *Polygonum amphibium* L. occurred (Fig. 1).

In the shallow part between the wooded area and the open water, we have found the grass *Ranunculus trichophyllus* CHAIX.

Fig. 3

The area inundated became full of reed-grass in a comparatively short time, and this process is, of course, the most considerable in the water-covered flood-plain wood. The available nutritive material is of very large quantity (B. TÓTH—VÉGVÁRI 1975), it can be considered therefore as an ideal place for the hair-weed vegetation and filamentous algae.

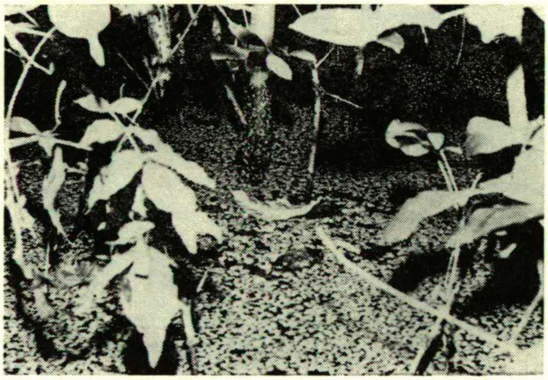

Fig. 4

After the flood-plain wood had got under water, as a result of foods washed from there, the rise in trophity was indicated first of all by the invasion of the phytoplankton multiplied quickly (HAMAR 1975).

In the growing period, the macrophytes began to dominate more and more, thus the accumulation of nutrients was realized in these, in contrast to the open water.

The infiltration of the nutritive materials enriched in the water may be manifold. It is always determined by the ecological situation, which group takes part, and to what extent, in the course of eutrophication. In our experimental area, in the open water, a considerable multiplication of the phytoplankton followed. Owing to the low number of macrophytes, we may speak of a process of *planktonic eutrophication.*

At flooding the wooded areas, the quickly-soluble nutritive materials were favourable to the phytoplankton (planktonic eutrophication), but only for a short time because, owing to the shading effect of the woody-bushy area and the smal water mass, the filamentous algae settled dow on the branches and tree-trunks, and later the macrophytes multiplied considerably.

In case of the filamentous algae we may speak of a *biotectonic eutrophication* (biotecton = the community of organisms living in bed-alien, subaquatic substrates, well-separable from the river-bed, being a member of the *benton* (LAKATOS 1975).

The nutrient-intake of the water macrophytes is different. The floating, rootless plants take in nutritive materials immediately from water *(pleustonic eutrophication)*, while the nutrient-intake of the rooted plants from water is carried out through some substrate *(rhizobenthic eutrophication)*.

The destruction of macrophytes may result in the release of a part of nutrients and the acceleration of filling in the ecosystem. The release of the nutritive materials — in however slow rhythm it takes place — may set in motion a recent cycle while the detritus accumulated may promote the settling down of recent macrophytes.

Depending on the way of the nutritive material, there are possible different types of eutrophication, namely:

plankton — planktonic eutrophication,
benton — biotectonic eutrophication,
rhizobenthic eutrophication,
pleuston — pleustonic eutrophication.

The nutrient infiltrating into the system can be used, on principle, by any vegetable group taking place in whichever niche.

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ZOOPLANKTON INVESTIGATIONS IN THE DAMMED RIVER TISZA REACHES

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Abstract

The paper is giving a faunistic-ecological elaboration of the Zooflagellata, Rotatoria, and Crustacea plankton of the dammed Tisza. It is analysing the effect of the river-bed damming and inundations upon the fauna.

Introduction

In the Middle Tisza Region (404 river-km) a river barrage was built and above it a shallow-water reservoir of 127 sq.km surface (water depth: 2.5 to 4.0 m) was established. The reservoir will be filled up in a few years. For recognizing the supplying water-course in advance and protecting the water quality of the reservoir, our laboratory has performed detailed hydroecological investigations since 1973. Within the framework of the work, we made hydrographical, hydrological, physical surveys (VÉGVÁRI 1975), carried on hydrochemical studies (B. TÓTH 1975, VÉGVÁRI 1975), bacteriological and algological (HAMAR 1975), as well as zooplankton investigations.

In the course of the zooplankton investigations, we have systematically studied the Zooflagellata, Rotatoria, and Crustacea plankton. The elaboration of the Zooflagellata fauna was carried out by my colleague J. HAMAR. I wish to express him my thanks, in this way, too, for having abandoned me his results.

Regular investigations were begun in April 1973. Our samples were collected from the reaches of the Tisza between Tiszacsege (at river-km 456) and Tiszaroff (at river-km 380). We have elaborated the Rotatoria and Crustacea fauna of the river by using the filtrate of 50 to 100 l water ladled, from the five sampling points designated, every fortnight. For investigating the planktonic Zooflagellates we have used ladled samples.

Zooflagellata fauna

Zooflagellates occurred in the dammed up water of the river, except for the winter months. In the course of investigations, we identified altogether eleven species. These are:

Bicoeca cylindrica (LACKEY) BOURR.
Bicoeca lacustris J. CLARK
Bicoeca sp (nova?)
Codonosiga botrytis (EHR.) KENT
Codonosiga longipes STOKES

Collodyction tricilliatum CARTER
Histonia velifera (VOIGT) PASCHER
Monosiga ovata KENT
Rynchomonas nasuta (STOKES) KLEBS
Salpingoeca buetschlii LEMM.
Stelexomonas dichotoma LACKEY

There were found first of all backwater species; in a water of higher suspended matter content we found only *Stelexomonas dichotoma* having rather strong lorica. The individual number of species fluctuated between 6 and 60 thousand ind./litre. Organisms designating polluted water were not found in the living samples, either.

Rotatoria and Crustacea fauna

About the Rotatoria and Crustacea fauna of the Hungarian Tisza Region we find some informations in the publications of ÁDÁMOSI *et al.* (1974), ÉBER (1955), GÁL (1963), and MEGYERI (1955, 1957, 1970). The fauna of the tributaries discharging into the Tisza (MEGYERI 1972), that of the backwaters (MEGYERI 1961) and of the borrow area of the Tisza (VARGA 1928, 1930) was similarly studied by a number of researchers. Most of the investigations so far have been carried out in the summer period. Our data concerning the autumn, winter, and spring periods are, therefore, defective enough.

In the course of our investigations lasting almost for two years, there were found 76 Rotatoria, 16 Cladocera, 2 Calanoida, and 10 Cyclopoida taxons. The enumeration of the species detected is contained in the following list:

Rotatoria

Anuraeopsis fissa (GOSSE)
Asplanchna priodonta GOSSE
A. siboldi (LEIDIG)
Brachionus calyciflorus var. *dorcas* (GOSSE)
Br. cal. var. *dorcas* f. *amphiceros* (EHRB.)
Br. cal. var. *dorcas* f. *anuraeiformis* BREHM
Br. cal. var. *dorcas* f. *spinosa* (WIERZEJSKI)
Br. angularis GOSSE
Br. bennini LEISSLING
Br. budapestiensis DADAY
Br. diversicornis (DADAY)
Br. falcatus ZACHARIAS
Br. leydigi var. *quadratus* ROUSSELET
Br. leydigi var. *tridentatus* f. *tripartitus* LEISSLING
Br. quadridentatus f. *typica* HERMANN
Br. quadridentatus var. *brevispinus* EHRB.
Br. quadridentatus var. *cluniorbicularis* SKORIKOV
Br. quadridentatus var. *latissimus* SCHMADRA
Br. quadridentatus var. *rhenanus* (LAUTERBORN)
Br. urceolaris O. F. MÜLLER
Br. rubens EHRB.
Cephalodella gibba (EHRB.)
Colurella adriatica EHRB.
Conochilus unicornis ROUSSELET
Dicranophorus caudatus (EHRB.)
Epiphanes pelagica JENNINGS
E. senta O. F. MÜLLER
Euchlanis dilatata EHRB.
Filinia brachiata ROUSSELET
F. longiseta (EHRB.)
Kellicottia longispina (KELLICOTT)
Keratella cochlearis cochlearis (GOSSE)
K. cochl. var. *irregularis* f. *angulifera* LAUTERBOR
K. cochl. var. *hispida* f. *pustulata* (LAUTERBORN)
K. cochl. var. *macracantha* LAUTERBORN
K. cochl. f. *micracantha* LAUTERBORN
K. cochl. var. *tecta* (GOSSE)
K. guadrata (O. F. MÜLLER)
K. guadrata var. *reducta* FADEEW
K. testudo (EHRB.)
K. valga (EHRB.)
Lecane bulla (GOSSE)
Lecane luna (O. F. MÜLLER)
Lepadella acuminata (EHRB).
L. ovalis (O. F. MÜLLER)
L. patella (O. F. MÜLLER)
L. rhomboides (GOSSE)
Lophocharis salpina EHRB.
Mytilina ventralis var. *brevispina* EHRB.
Notholca acuminata EHRB.
N. squamula O. F. MÜLLER
Paradicranophorus hudsoni GLASCOTT
Pedalia mira (HUDSON)
Platyias patulus (O. F. MÜLLER)
Polyarthra dolychoptera IDELSON
P. euryptera WIERZEJSKI
P. longiremis CARLIN
P. major BURCKHARDT

P. remata SKORIKOV
P. vulgaris CARLIN
Pompholyx sulcata HUDSON
Rotatoria neptunia (EHRB.)
R. rotatoria (PALLAS)
Synchaeta grandis ZACHARIAS
S. longipes GOSSE
S. oblonga EHRB.
S. pectinata EHRB.
Testudinella patina (HERMANN)
Tetramastyx opoliensis ZACHARIAS
Trichocerca bicristata (GOSSE)
Tr. birostris (MINKIVICZ)
Tr. dixon-nutalli (HENNINGS)
Tr. longiseta (SCHRANK)
Tr. pusilla (JENNINGS)
Tr. rattus (O. F. MÜLLER)
Trichotria pocillum (O. F. MÜLLER)
Wolga spinifera WESTERN

Crustacea

Cladocera

Alona rectangula SARS
Alonella nana (BAIRD)
Bosmina longirostris (O. F. MÜLLER)
Ceriodaphnia laticaudata P. E. MÜLLER
C. pulchella SARS
C. reticulata (JURINE)
Chydorus sphaericus (O. F. MÜLLER)
Daphnia cucullata SARS
D. hyalina var. *lacustris* SARS
D. longispina O. F. MÜLLER
Leptodora kindtii (FOCKE)
Moina rectirostris (LEYDIG)
Pleuroxus aduncus (JURINE)
Scapholeberis murconata O. F. MÜLLER
Simocephalus vetulus (O. F. MÜLLER)
Simocephalus exspinosus var. *congener* SCHOEDLER

Calanoida

Eudiaptomus gracilis G. O. SARS
E. graciloides LILLJEBORG
copepodit, nauplius nymph

Cyclopoida

Acanthocyclops robustus C. O. SARS
A. vernalis FISCHER
Cyclops strenuus FISCHER
C. vicinus ULJANINE
Diacyclops bicuspidatus CLAUS
Eucyclops serrulatus FISCHER
E. speratus LILLJEBORG
Megacyclops viridis JURINE
Mesocyclops leuckartii CLAUS
Thermocyclops oithonoides G. O. SARS

It is to be established from the enumeration above that the Rotatoria fauna of the Tisza is formed in its majority by ubiquitous species. The high number of the taxons of the genera Brachionus and Keratella having strong shells is particularly striking. Comparing our data to the results of the earlier investigations, it turns out too, that the species combination — in relation to the state between 1951 and 1967 — has not changed. This is also a proof for that the Tisza has a proper, autochtonous plankton formed by some species tolerating the aquatic conditions of life more or less well and being able to multiply there. A great number of the organisms, not found in the Tisza so far *(Brachionus budapestiensis, Epiphanes pelagica, Lepadella acuminata, Paradicronophorus hudsoni, Polyarthra euriptera, Syncheta grandis)*, were given by the species getting in from the flood-plain on the occassion of indundations. The occurrence of *Wolga spinifera* in the Tisza is an interesting event; in the Carpathian Basin it is only mentioned from the basin of the river Garam by VARGA (1957). Almost each of the Rotatoria species living in the Tisza is a member of the Danube plankton, as well (KERTÉSZ 1963, KOL—VARGA 1960).

The dominant species of the summer Rotatoria plankton belong to the genera *Brachionus, Filinia, Keratella* and *Polyarthra*, and the characteristic organisms of the autumn, winter, spring period to the genera *Notholca, Polyarthra* and *Synchaeta.* On the basis of the occurring species, the river may be classified to the-b-mesosaprobic category although the presence of Epiphanes senta is referring to a more than average pollution.

By reason of the literary data (MEGYERI 1972), the Rotatoria plankton of the Tisza is not influenced considearbly by the tributaries, except the Sajó, as the species combination of these tributaries, as well, is similar to that of the Tisza. The water quality of the Sajó improved certainly much of late years. This establishment is proved also by the nine Rotatoria and one Crustacea species found in the spring period (March 22nd, 1974), especially if taking into consideration that during the investigations in the years 1950 and 1956, MEGYERI (1972) did not find any taxon at all belonging to this group.

The number of the species Cladocera and Copepoda occurring in the Tisza is high. The species combination of the Crustacea fauna is strongly influenced by shallow lenitical water spaces formed after damming up beside the backwaters, borrow areas and canals and are in occasional connection with the river (MEGYERI 1971). According to our observations, they get from these places from time to time in large numbers into the current of the river, and keep on living there. The autochtonous Crustacea fauna of the Tisza is formed by the well-accomodating species of wide ecological valence getting from the river environment appropriate living conditions.

In the river reaches investigated, from Cladocera the species *Bosmina longirostris, Moina rectirostris,* and *Simocephalus vetulus* may be considered as comparatively permanent plankton members.

From Copepods, *Acanthocyclops vernalis, Cyclops strenuus* and *Thermocyclops oithonoides* are regularly occurring members of the Tisza plankton. The existence of the individuals in different stages of development (nauplius, copepodit) and of well-developed individuals with ovules is proving their multipliability under conditions of the Tisza.

In case of a permanently small water output, the conditions of a considerable multiplication of any investigated zooplankton groups are assured in the reaches dammed up.

Rotatoria and Crustacea occur in the whole year, although in the period of floods the amount of Cladocera is as a rule very small, and even they are missing from time to time.

In 1974, in the small-water period in Spring, the Tisza was populated by cold-water species *(Notholca squamula, Synchaeta oblonga,* etc.*)*. In that period, the zooplankton number was about 500 to 600 ind./100 litres value. The summer flood

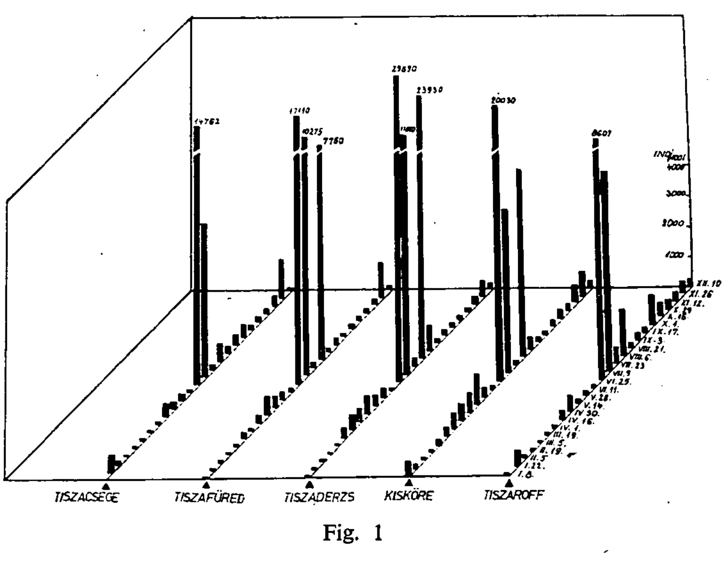

Fig. 1

substituted species drifted in from the flood-plain for the species existing there earlier. In the period of the flood passing, the zooplankton count reached 20 thousand ind./100 l, and from time to time even surpassed that (Fig. 1).

After the flood-wave passing, in the autumn period, the zooplankton count was low, then at the end of November it was higher.

A change in the character of water (pollution, speed of flow, turbidity, etc.) involved a change in the combination of the species- and individual numbers of the zooplankton, as well. The systematic investigations enable us to follow the changes in the hydroecological peculiarities of the Tisza, on the basis of the permanent disappearance of one or more species or the appearance and prevalence of other ones. If treating the data with due reservation, we can conclude the future formation of the zooplankton, too, from the transformation of the environment, in our case from bringing about damming and then from the storage in the reservoir. The species Rotatoria and Crustacea, found in a comparatively high number in the course of studying the zooplankton of the river and having generally a considerable individual density in the plankton of backwaters, will certainly exert a positive influence upon formation and "stabilization" of the zooplankton of the Kisköre Reservoir built at the Tisza. The multiplication in large numbers of the species living in the river, as well as in its backwaters, and borrow areas will be promoted by the standing-water conditions to be developed in the reservoir.

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DIURNAL PLANKTON INVESTIGATION IN AN EXPERIMENTAL AREA, IN THE REACH OF THE KISKÖRE RIVER BARRAGE

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Abstract

The total bacterial number showed no significant change during the investigation. The algological investigations demonstrated a eutrophic phytoplankton of stable species and individual count where the change was indicated by the migration of flagellatae and the progressive increase in the individual number of Chlorophyceae. The vertical migration of the Rotatoria resp. Crustacea plankton is considerable, as well.

Introduction

The diurnal investigations give information on the biological and chemical rhythm, dynamism of some water area. Conclusion may be drawn concerning the stability of the ecosystem, the trend of its development. Connecting the modification of stratification with vertical measurings, we can recognize the degree of the vertical migration. At investigating unstable systems, it is particularly important to study the oxygen — carbon dioxide circulation and the factors influencing it in a dierct way. In the area beside the Kisköre River Barrage we have investigated the effect exerted by the inundated woody part on the quality of water (B. TÓTH 1975, BANCSI 1975, HAMAR 1975). In the course of our diurnal investigations, we have also studied the dynamism of the chemical parameters (BANCSI and KATONA 1975).

Method

The total bacterial number was determined with a membrane-filter technique (FELFÖLDY 1974). The *Planctomyces bekefii* GIM. number and the algological investigations were carried out with Utermöhl's technique, the quantity of zooplankton was determined in a counting chamber. Surface samples were taken in every three hours, on September 17th, 1974 between 0—24 o'clock, from the open-water parts of the experimental area, at a sampling point. The results of chlorophyll content were placed at our disposal by MÁRIA B. TÓTH. We should like to record our gratitude for her kindness.

Results

The total bacterial number was changing between 13.9—15.3 million ind./ml, showing no evaluative dynamism. The individual count of *Planctomyces bekefii* GIM. is changing but the changes are not significant (Tab. 1).

The qualitative composition of algae is as follows:

Cyanophyta	5
Euglenophyta	10
Pyrrophyta	7
Chrysophyceae	8
Bacillariophyceae	11
Xantophyceae	1
Chlorophyta	47
Sum total	89

The difference from the average species number is but a minimum.

It appears from the quantitative analyses that the dominance and abundance values give a similar result (Fig. 1).

From among the species of the two dominant groups Chlorophyta and Chrysophyceae, the individual count of *Ankistrodesmus falcatus* and other cosmopolitan species, as well as that of *Chrysococcus biporus* is high. More than 30 per cent of the species, and among them the dominant species, occur in every sample. The total algal count and dominance of the stand of high individual count are comparatively stable,

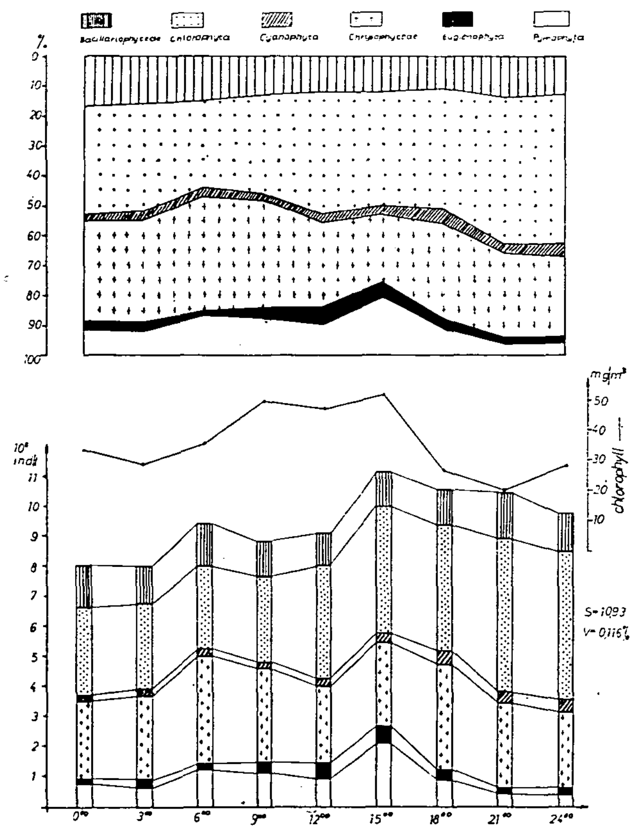

Fig. 1. Dynamism of the individual number and percentage distribution of phytoplankton. Change in the chlorophyll content.

the relative dispersion (v) being 0.116 per cent, S = 10.93. A change can be observed in the day-time hours concerning the increase in the individual count of the species Euglenophyta and Pyrrophyta that are capable of changing their place actively (Tab. 1). The increase reaches maxima in the early afternoon. The samples were taken in a sunny weather. The positive phototaxis of some flagellatae may be supposed. In the vertical migration of small waters, as well, flagellatae do play a part (Iyengar 1933, Philipose 1959). The gradual increase of Chlorophyceae is equally shown by both the dominance and abudance values (Fig. 1). The fortnightly systematic investigations (HAMAR 1975) did indeed show in that period an increase in stand.

The chlorophyll content changed between 20—50 mg/cc.m. A rise could be observed in the day-time hours. But there is no correlation between the total algal count and chlorophyll content.

Their number is higher in the night horus, in the afternoon it is lower in the surface-water layer.

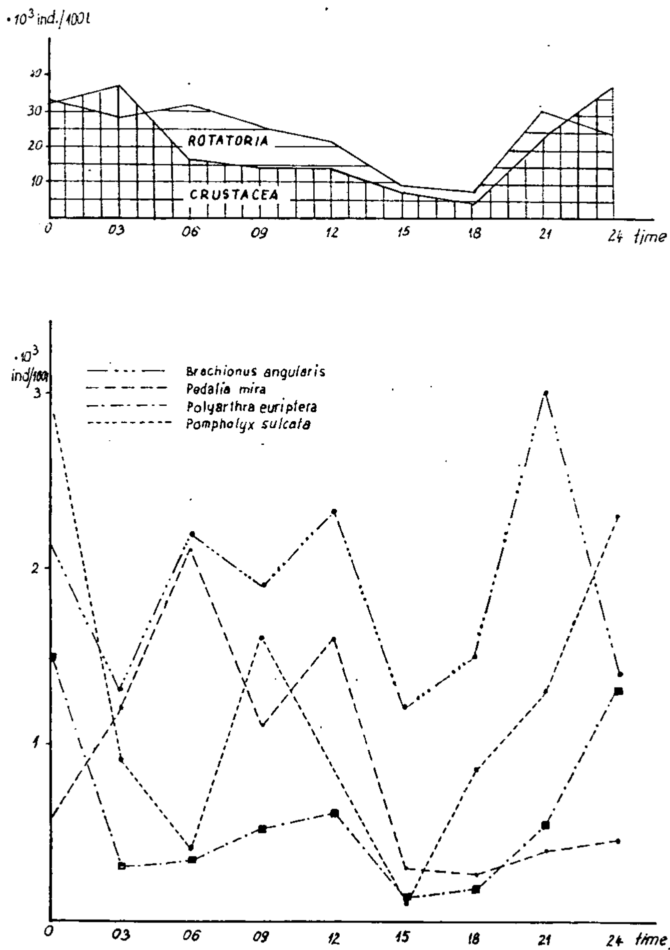

Fig. 2. Quantitative dynamism of the Rotatoria and Crustacea plankton. Migration of some Rotatoria species according to the hour of the day.

In the samples dipped out of the water surface given, the species- and individual-counts of zooplankton were considerably different from each other in the various hours of the day (HYMEN, L. H. 1951, BAYLOR, E. R.—SMITH, F. E. 1957, ARORA, H. C. 1965, GEORGE, M. G.—FERNANDO, C. H. 1969, KUTIKOVA, L. A. 1970). The study of zooplankton in this way is made more difficult by that these organisms can wander not only vertically but horizontally, as well. In order to evaluate correctly the zooplankton stand of a water surface, possibly on the basis of point-samples, too, we had to deal with the subject of the wandering according to the parts of the day under the conditions in this country.

Evaluating the results of the investigations of the Rotatoria and Crustacea plankton in the surface samples dipped between 0 and 24 o'clock on September 17th, 1974, we observed in case of several species some changes in the individual count from which their vertical wandering could be concluded (Fig. 2).

The Rotatoria-plankton was the least dens between 15—18 o'clock while at night their count was considerably larger. We have observed a more or less regular rhythm in case of species *Brachionus angularis, Pedalia mira, Polyarthra euriptera, Pompholyx sulcata* (Fig. 2).

The Crustaces number in Case of Rotatoria took shape in a similar way as observed: at night their count is higher, in the day it is lower in the surface-water layer. From among the *Cladocera* species, only *Bosmina longirostris* was found in all the samples. The species *Ceriodaphnia megops, Moina rectirostris* were only found in the night hours.

The single *Cyclopoida* species, found on the occasion of the investigation, showed the maximum individual count similarly in the night hours.

On the basis of the results of the 24-hour zooplankton investigation it seems so that the migration of the species Rotatoria and Crustacea according to the hour of the day is fundamentally influenced by (the strength and possibly the angle of incidence of the) light. The Rotatoria and Crustacea number may reach in the night hours even the treble of the values experienced in the afternoon hours. At the majority of the species found we have observed a negative phototaxis. In case of surveying, thorough-going investigations (at ethological and phenological estimations) the hours of the day of the immigration of species, and therefore the numerical differences resulting from the immigration, must needs be taken into consideration, as well.

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